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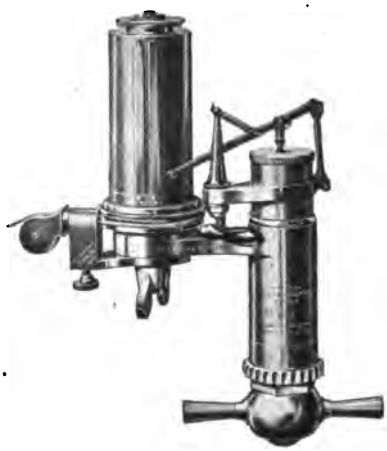

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The photograph was taken in February, 1908

CULEBRA CUT, PANAMA CANAL

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YEAR BOOK
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UNIVERSITY OF MINNESOTA

APRIL, 1908 VOLUME 16

STUDENT ENGINEERS AND THEIR WORK.

By Edward J. Cheney, E. E., '04.

It is quite generally supposed that the technical student has already decided upon his life-work, and, upon graduation, has only to step into some position which is waiting for him. Unfortunately the problem is not so simple. Instead of one there are likely to be a dozen jobs, each of which offers a different line of work and, even if it were possible to know all about each place, the choice would still be perplexing enough. Far from knowing all, the student usually knows very little and has small opportunity to find out more regarding the different openings. He knows it is of utmost importance that he choose the one best suited to his tastes and capabilities, that it may lead to that success of which he has long dreamed and for which he is already working. To describe as fully as possible one of the principal alternatives in order that he may intelligently choose regarding it is the object of this paper. If those who have already completed their college education and chosen life tasks find anything of interest it will be gratifying to the author, but his special thought is for the under graduate.

It is universally recognized that the modern engineer must be college trained and just as generally recognized that after this training he should have experience in practical work. To have this practical training directed, encouraged and hastened is of equal benefit to employer and employe. To that end our large companies have made provision for a special "course" which is so valuable that it is considered practically essential for each engineering employe to have taken it. So

many men annually enter these courses that they have become of first interest to those about to leave school and enter business. Due to its peculiar need for trained men, the electrical industry leads in the thoroughness with which its courses are organized. But all lines of manufacturing and operating have awakened to the value of such training and have well developed and constantly growing departments for the work.

As a basis for this paper, there has been available complete data regarding student engineers at the Schnectady works of the General Electric Company. Further than this, the writer has many acquaintances who are or have been in such work at various places and has in recent years been through the mill himself. The endeavor will be to give things as they appear to the average man and to eliminate the writer's personal opinions as far as possible in order to make the information useful to the greatest number.

First, as to the objects. It must be remembered that in these courses there is no pretense of philanthropy. It is a commercial proposition entirely. The company has a double purpose. It wants to give its new men practical experience and educate them in the details and methods which it uses. It also needs a means of sorting the raw material and picking out that which it can use to best advantage. The man usually has one main object in mind, which is to get a training in construction and operation. Before he gets through he discovers that many other advantages come to him and what these are will develop later. What he should impress himself with first and all the time is that he is part of a commercial machine which expects him to play his part; that sentiment has no place and that before he is advanced he must show his capacity for the larger place. Because his work is so much like a post graduate course does not mean that he is still under school regime. Everything he does is for some practical purpose and while he is picking up information he is expected to make himself useful.

Student engineers at the Schnectady works are supposed to put in about two years. This is subject to considerable variation in individual cases. The first two months are spent in some one of the shops on assembly work. This work is done by gangs of regular employes and the student is simply one of the gang while with them. A good idea of mechanical construction and methods of setting up and tearing down machines are gained here. The remainder of the time is spent in the testing department. The whole course is usually

spoken of as "the test" and the student engineers are commonly called "testers" or "test men."

The testing department is a regularly organized department which comes under the jurisdiction of the electrical superintendent of the company. In immediate charge of it there is a division superintendent who has under him the foremen and heads of sections of the department. Its duty is to see that every piece of apparatus manufactured at the Schenectady works is tested and found to be satisfactory and according to specifications, as well as to make special tests and do experimental work for the benefit of the designing engineers.

All machines of new design and a certain per cent of standard apparatus are given complete tests under conditions as nearly like those of actual operation as it is possible to obtain in the factory. Part of the standard apparatus whose performance is well known is merely given "compromise tests" to insure the satisfactory condition of mechanical parts. Men in the department work fifty-five hours per week on day work and sixty hours per week on night work. The day hours are from 7:00 a.m. to 5:30 p.m. with a half-hour for lunch at noon and a half-holiday on Saturday. Night men work from 7:00 p.m. to 7:00 a.m. five nights per week, a half-hour being allowed at midnight for lunch but not deducted from their pay. The time from 5:30 to 7:00 p.m. is bridged over by enough day men working overtime to watch whatever machines are running. Night work is necessary in the department as machines started on heat runs must be continued till constant. As the pay per week for night work is slightly higher than for day work and the long week end holiday is much enjoyed, night work is sought by many. Each man is liable to be put on night work for three months in each year unless it injures his health.

When it is considered that the General Electric Company turns out some fifty to sixty millions of dollars worth of apparatus annually, the greater part of which comes from the Schenectady works, and that this product ranges from small circuit breakers and fuses to 100,000-kilowatt transformers and steam turbines, it will be seen that the testing department has immense responsibilities and abundant opportunities for one seeking to gather experience. The department receives machines in a finished but not assembled state and has them in charge until they are tested, painted and turned over to the shippers for crating. The work of assembling, fitting, lining and tearing down machines is done by mill-

wrights and laborers. The real work of testing is all done by the student engineers. At least ninety per cent of these are technical graduates recruited from the colleges of this and all other countries. The non-technical men are fellows who have shown particular aptness and have served an apprenticeship of a year or more in inferior positions in the department and have passed an examination indicating that they have a good general knowledge of electricity.

For convenience of testing, the department is divided into sections, each of which has its particular kind of apparatus to handle. Thus there are the induction motor section, the transformer section, the steam turbine section, etc. In charge of each section is a head who has one or more assistants. These are all men who have risen from the ranks and are working up to places as assistant foremen, or getting a wider experience before going on to a place in the general offices or elsewhere. They have considerable responsibility and the chance to gain experience in executive work, coupled with the increased pay, makes their places eagerly sought. In order to give the men as varied an experience as possible they are moved from section to section, a definite time being allotted to each, depending upon the nature of the work. As there is something of a similarity in the work of different sections, a man does not care to take work in all of them. His own wishes are given much consideration and in the scheduled time a man may get a very complete experience in every line.

It is not possible in this space to describe in detail the work of testing, but some idea of the way it is handled may be given. A machine having come to test in any section, the head of the section selects one of his men of sufficient experience and capability and assigns the machine to him. This man is held responsible for the test. He has as many others to help him as the nature of the test requires. It naturally follows that the most experienced men on each test are running machines while the newest ones are "holding speed" and "pulling water box." The man in charge discovers what tests are required and directs his helpers in wiring up the machine, securing proper meters, etc. Having everything in readiness he proceeds to take the tests and record the readings on special sheets provided for the purpose. Throughout the test he is held responsible for all the apparatus with which he is working. He must see that the wiring is correctly and safely done, that the bearings are lubricated, the belt is safe and that readings are complete and accurate. Before starting the machine up he must inspect it for mechanical defects

and determine that it is, so far as can be seen, ready to run. The head of section and assistants will be somewhere near and ready to give advice and assistance, but this does not relieve the tester from responsibility. He has instruction books giving complete description of methods and, by asking, can find out anything he is uncertain of, and is expected to do so. If it is a compound motor he is testing he is expected to know before starting it whether it is connected differentially or accumulatively, whether it has oil in the wells or not and everything else which he should know while it is running.

This matter of responsibility cannot be made too strong. It is one of the best things the men get. The fact that they are responsible makes them more thorough and careful and so they learn much more than they otherwise would. They learn to investigate, to make sure of things and to have confidence in themselves. It is one thing for a man to see a machine which he knows has been run for years and to start it by throwing a switch which has been thrown hundreds of times before. It is quite another thing to wire and start a rough, unpainted machine, fresh from the shops, whose parts have never seen each other until an hour before, and which has never felt the thrill of current. By the time a man has done this with machines of all kinds and sizes he knows something of their practical operation and is not afraid to handle anything under any circumstances.

This practical experience is invaluable to the average graduate. He comes out of school with a fine knowledge of fundamental principles and a lot of theory, which helps him to work intelligently and effectively. But the chances are that, aside from a few small machines in the laboratory, he has never actually handled any electrical apparatus and would be very much at sea if put in sole charge of a small lighting plant. His theory needs reinforcing by practice to make it a handy tool for ordinary use. No amount of college training will teach him to protect a motor field or watch the load on a series motor as will once seeing a machine start to run away. Nothing will teach him how to care for a commutator, watch the end play, or shift brushes, as will doing these things himself.

Mechanical design and practical operation are so important in all electrical work from operating to designing that a thorough understanding of them is of vast benefit. The tester has a chance to familiarize himself with construction of

all types and sees the latest designs in operation before any one outside the factory can do so.

While in the department, a man meets and works with men from all over the globe. He gets their views and ideas and studies their peculiarities. He measures himself by them and finds whether he comes up to standard or not. In the course of time he has machines to run and men under him. He learns to plan work and direct men, to foresee danger and act quickly in emergencies. The data on performance of machines and ideas of operating characteristics are very valuable but are, in the writer's opinion, surpassed by the other things mentioned.

During his time on the test, a man gets sufficient wages to keep him in quite a comfortable way. He has the privilege of clubs, lectures and association with a fine lot of college men to make his leisure hours enjoyable. During his working hours he works hard. Dragging heavy cables and carrying resistance boxes are neither easy nor clean jobs, and there is lots of such work to be done. After his day's or night's work he goes home tired and dirty. No one who is looking for a soft snap need come to the department and none such are wanted there. Men who have the energy and courage to take things as they come and work hard will be accorded the treatment due to gentlemen and will be surprised to find how well their work is recognized. To the man who is looking for what he can learn, the work is absorbingly interesting and far from disagreeable.

Naturally the question arises as to what a man has to look forward to after completing the course. One or two years hard work give him valuable experience but what chance has he to use it? As intimated before, if his work has been satisfactory the company has a place for him. During his time on the test very close watch has been kept on him and his work. It is well known whether or not he is reliable, conscientious, industrious and intelligent. The test foreman probably knows better than the man himself what line of work he is best fitted for, although his own inclinations are ascertained and considered. When any department head needs a man he applies to the testing department for one. Someone who wishes that kind of work and is considered best fitted for it is sent up to the department head for a personal interview. The head has an opportunity to judge his man and the man has an opportunity to ascertain the nature of the work. If mutually satisfactory, a salary is fixed and the transfer to office work made. In the different departments are to be found a wide range of

duties so that almost any taste can be suited. Once started in one of them, a man's further progress depends upon himself.

The company's customers are constantly calling for competent men, familiar with the apparatus, to take jobs in their employ and the company wishes to supply the demand as far as possible. Many men go direct from the test to such positions. Others work in the office for a time and pick up a knowledge of executive routine before going to the outside position. Naturally many men find places for themselves. In doing so, the fact that they have had the testing experience is a most valuable asset and probably their strongest recommendation. There are few users of electrical apparatus who do not know the company's reputation and the care with which it trains its technical men.

The following table shows what became of the men who left the testing department during 1906 and 1907:

	1906	1907
Engineering Department	63	25
Drafting Department	16	29
Commercial Department	31	25
Construction Department	28	20
Other offices	21	27
Outside positions	48	87
Miscellaneous	79	55
Total	286	268

During 1906 there was an average of 475 men in the student engineering course, and during 1907 an average of 490. This would indicate an average time in the course of about one and three-quarters years. Those who go into the drafting room do so for a few months only and for the purpose of getting experience in details and methods of mechanical design. They usually have arrangements made for entering an engineering department before they leave the test.

Of course, there are a certain percentage of failures. Many men are unfortunate in choosing their work and spoil what otherwise might be successful lives by trying to be engineers when they ought to be farmers. The blame for these cannot be laid to the system, though some of the victims may think it should be. Criticism may always be expected from the unsuccessful just as the discontented poor man may be counted upon to vote against the administration. This must be expected so long as human nature remains as it is, but the fact that a surprisingly small number have any complaint or any regret

because of taking the course speaks eloquently in its favor. The company would be the last to say there were no defects in its system and is the most anxious to discover them. It goes without saying that when the company uses by far the greater number of these men in its own employ it puts forth every effort to make them as efficient as possible. It is equally evident that a man who is fitted for the wide interests of the company is well equipped for almost any other job.

Other companies have different arrangements as to the time and nature of work for their special employes, but all are looking to the same end and, so far as can be judged, accomplish about the same results. No such course can make a good man from poor material any more than a college can educate a man who cannot learn. And the man of really good ability will succeed without it just as he will without a higher education. But the point of success which any man may reach is determined largely by his training and we believe enough has been said to show that the student engineer gets a degree of knowledge, ingenuity and self-confidence which will materially boost his inherent potential and be of immense help in overcoming the resistance between him and his goal.

TANGIBLE PROGRESS ON THE PANAMA CANAL.

A Record of the Work Done on the Isthmus up to March, 1908.

By Oliver G. Tubby, '07.

Four years have passed since the original act of congress authorizing the construction of the Panama Canal was signed by President Roosevelt. It may now be fairly stated that the preliminary and experimental work necessary to get this great enterprise properly under way is finished and that appreciable, tangible progress has been made toward the ultimate completion of the canal.

What the people of America wish to know today is: How much progress has been made toward a finished canal? Just what is the present condition of the work on the Isthmus? It is to answer these questions that the following article is written:

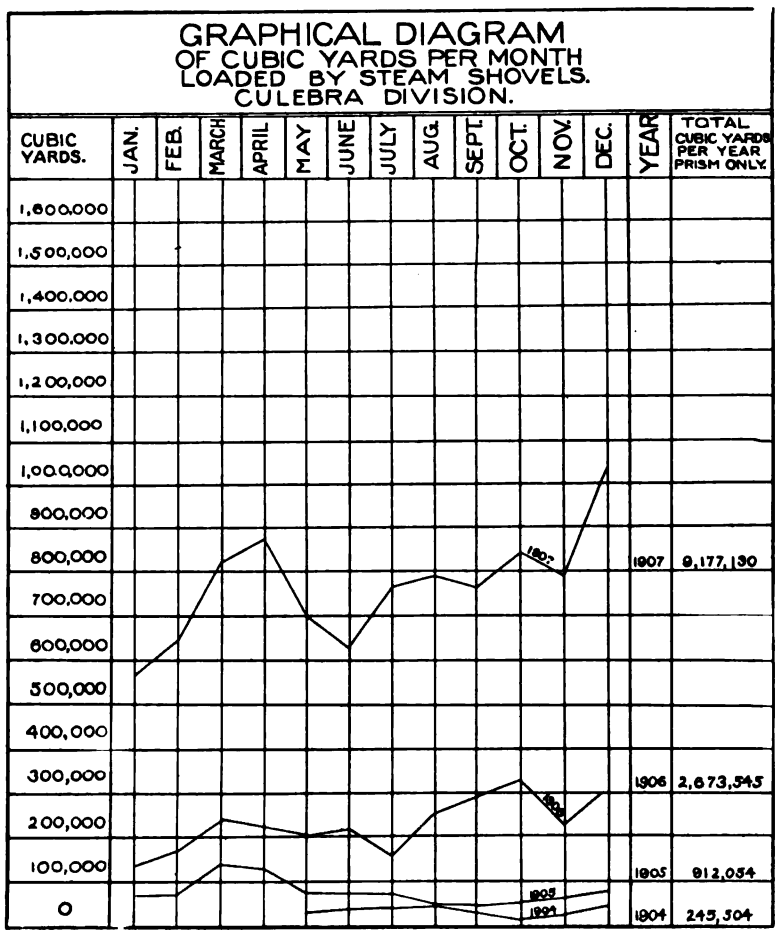
The United States bought the property of the New Panama Canal Company for the sum of $40,000,000, and the transfer of the property was made May 4, 1904. At that time the company had reduced its force to only about 700. The canal commission decided to continue the work then in progress, and gradually to increase the force for the purpose of making extensive surveys and investigations of various kinds for their estimates and better solutions. The sanitation of the Isthmus was also given special attention.

Numerous types of lock canals with different summit elevations, as well as a sea-level canal were considered, with regard to efficiency, cost and time to build. The final decision is to build a lock canal with a summit elevation of 85 feet.

A ship entering the canal from Limon Bay will proceed at sea-level through a 500-foot channel to the Gatun locks, a distance of 2.6 miles, or about 6 miles from deep water in the Atlantic. Here it will be lifted 85 feet by means of a flight of three locks, and will then sail forth upon Gatun lake, which will be formed by the Chagres river when the dam is built across the valley. This lake will have an area of 164 square miles when the surface is at elevation + 85. After passing over Gatun lake, the ship will arrive at Bas Obispo, 23 miles from the Gatun locks, where the channel becomes narrow and

BLASTING SOLID ROCK, PANAMA CANAL

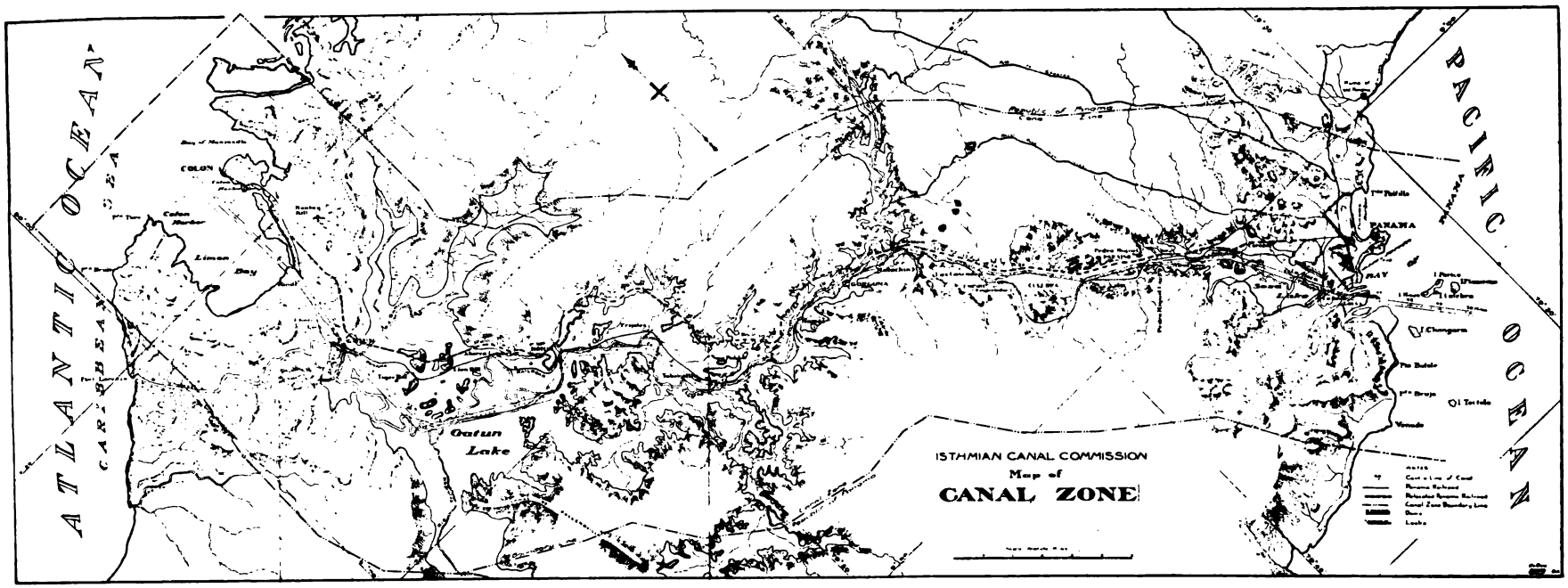
the cutting is through solid rock. This narrow channel is 200 feet wide at the narrowest place and about 10 miles long, extending through Culebra cut to Pedro Miguel, where there will be one lock to pass through, and the ship being lowered from elevation + 85 to elevation + 55, will then proceed about a mile and a half to Miraflores, where it will be lowered through two locks to sea-level, proceeding finally a distance of five and one-half miles to the Pacific ocean.



The construction work along the canal is divided into four divisions and the three sets of locks.

The Colon Dredging Division.

This division extends from deep water in the Caribbean Sea to the Gatun locks, a distance of between six and seven miles. On this division the estimated amount of material to


ATLANTIC OCEAN
CARIBBEAN SEA
PACIFIC OCEAN
COLON
PANAMA
BAY
Gatun
Lake
ISTHMIAN CANAL COMMISSION
Map of
CANAL ZONE

be removed is about 11,500,000 cubic yards, of which about 3,700,000 cubic yards consist of rock, the remainder is earth and mud, which will be dredged out.

Dredging in the Colon district has been in progress over a year. The old French canal has been dredged deeper and makes a good waterway for the transportation of materials to be used in the construction of the Gatun locks.

The dredging fleet in this division consists of one 16-inch suction dredge, two 5-yard dipper dredges, two old French ladder dredges, and the "Ancon," a sea-going suction dredge. Serving the dredges are six steel hopper barges, four old French self-propelling dump barges, called "Clapets," and one tug.

The total excavating in the Colon division since the American occupation to Feb. 1, 1908, was, by steam shovel 235,686 cubic yards, and by dredges 4,540,080 cubic yards.

The machine shop for the Colon dredging division at Cristobal has been recently equipped with many new machines and is quite up-to-date.

The dry dock at Cristobal is being enlarged to accommodate a vessel 298 feet long, 50-foot beam and 15-foot draft.

The Chagres Division.

The Chagres division extends from deep water of Gatun Lake to the point where the canal crosses the Chagres river near Bas Obispo, a distance of 21 miles. The work on this division has been so far mostly preparatory, consisting of surveys and borings, to determine the amount and character of excavating necessary. The total amount of excavating to be done on this division is estimated roughly at 13,000,000 cubic yards, of which 5,000,000 cubic yards consist of rock. A number of steam shovels are at work in the rock vicinity of this division.

The Chagres river crosses the center line of the canal 23 times within the limits of this division, so that the work is subject to interruptions due to the floods of the river.

The Culebra Division.

The Culebra division joins the Chagres division near Bas Obispo, and extends to Pedro Miguel, a distance of 9¼ miles. It is within these limits that the deepest cutting is being done. The French excavated 17,000,000 cubic yards from the canal prism in this vicinity in 18 years; the Americans have already excavated, Feb. 1, 1908, 14,264,869 cubic yards, and there remains, including the Pedro Miguel locks, about 44,000,000

cubic yards yet to be excavated. The material is being excavated by steam shovels and is hauled away on dirt trains an average distance of 10 miles, but this distance will be increased as soon as the dams require the material. A large amount of the material to be removed from the Culebra division is solid rock and necessitates a large amount of blasting. The drills are furnished with compressed air supplied by three compressor plants pumping into a 10-inch main, nine and a half miles long. These plants contain, altogether, 12 compressors, each with a capacity of 2,500 cubic feet per minute at 100 pounds pressure.

The elevation of the bottom of the completed canal on the Culebra division is fixed at 40, the width of the base at the narrowest point will be 200 feet, and the depth 45 feet. The elevation of the surface of the water will be + 85, the same as in Gatun lake.

The La Boca Dredging Division.

The La Boca dredging division extends from the Culebra division to deep water in the Pacific ocean, a distance of about 11 miles. On this division there will be two sets of locks, one set will be located at Pedro Miguel, the other at Miraflores, seven and five and a half miles respectively from the Pacific ocean. Until recently the Miraflores locks were intended to be at La Boca, but it has been found by recent borings that a sea-level canal in as far as Miraflores will be far more economical, for the dam to be built there will be much shorter than that at La Boca, and the additional excavating in the sea-level channel will not be through solid rock as previously supposed.

The locks at Pedro Miguel will consist of but one flight, and those at Miraflores of two flights. They will both be built in duplicate and their construction will be similar to those at Gatun.

The total excavating done on this division to Feb. 1, 1908, was 4,280,425 cubic yards, but a considerable amount of this was outside of the canal prism, such as deepening the water at the docks.

The dredging fleet consists of two old French ladder dredges, one 5-yard dipper dredge, and one sea-going suction dredge, the "Culebra." The ladder and dipper dredges are served by seven old French self-propelling dump barges called "Clapets," and by three steel hopper barges of a capacity of 350 cubic yards each.

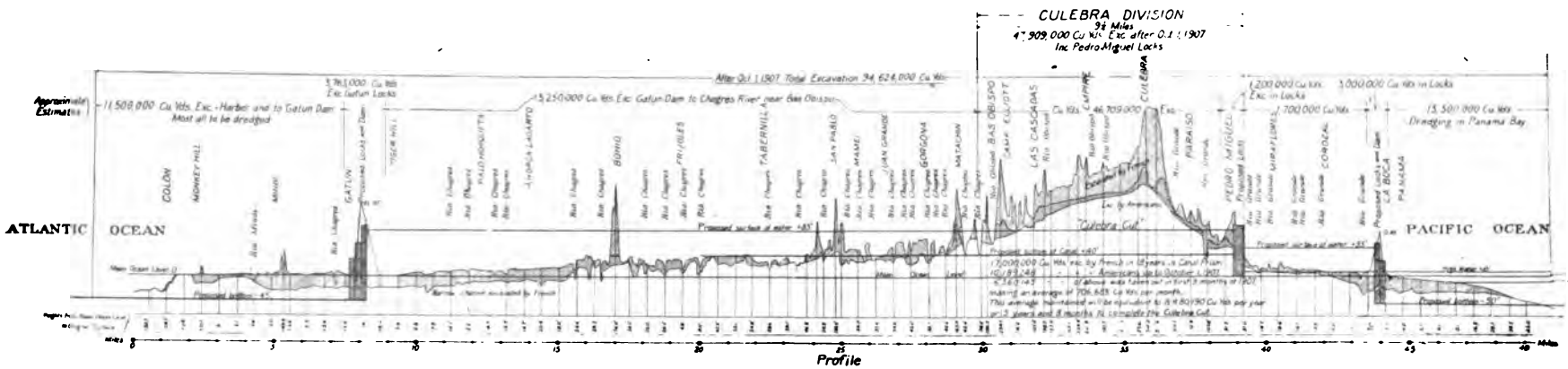
The Gatun Dam and Locks.

The controlling feature of the canal will be the earth dam across the Chagres at Gatun. This dam will form an inland lake with an area of 164 square miles and will receive all the floods of the Chagres and store the water to be utilized in operating the locks during the dry season. The immense dam will extend across the Chagres valley, and will be about one and a half miles long, practically a half-mile wide at the bottom, and 80 feet wide at the top, which will be 135 feet above mean tide, or 50 feet above the level of the water in Gatun lake. The up-stream toe of the dam will be weighted with a pile of rocks to elevation + 30 and a minimum width of 50 feet. There will also be a core of some impermeable material inside of the dam to prevent seepage. The down-stream toe of the dam will be built by means of a suction dredge. The material for this purpose is to be dredged from the channel between the Gatun locks and Limon Bay.

About midway in the length of the dam is a rise of ground through which a diversion channel will be excavated and the Chagres will flow during the construction of the dam. The dam will be provided with a spillway made of masonry, and will consist of a series of sluiceways closed by Stony gates. This spillway will control the level of the lake during floods and will be capable of discharging 140,000 cubic feet of water per second when the lake is not more than one foot above its normal level.

The locks are to be placed near the north end of the dam and will consist of a flight of three, built in duplicate, each with a lift of about 28 1-3 feet. The locks on the Pacific side will also be built in duplicate. This makes the canal practically double and able to accommodate ships going either way at the same time. Each lock will be 1,065 feet between gates, the usable length will be 1,000 feet, the width 110 feet, and the depth on the miter sill will be 40 feet. The gates will be in duplicate and of the miter type. A rolling gate will be substituted for the duplicate set at the lower end of each summit-level lock. There will also be provided: an auxiliary pair of gates at the lower end of each flight, to be used as coffer-dams in case it may become necessary to pump out the locks, and also a swing bridge type of dam for emergency use.

Numerous holes have been drilled and test pits sunk to determine the nature of the foundation for the locks. The base of the lower pair of locks will be 40 feet below sea-level. The total excavating done at Gatun to Feb. 1, 1908, was 1,-



Profile

PROFILE, PANAMA CANAL.

658,962 cubic yards, and there remained about 3,000,000 cubic yards yet to be excavated.

In the near future a large plant for manufacturing Portland cement will be erected at Gatun. It is expected that about 4,500 yards of concrete will be laid daily when the work of building the locks is commenced at all three sites. The cost per cubic yard will be about $8.00.

The Panama Railroad.

The present line of the Panama railroad runs from Colon across the Isthmus, in a southeasterly direction, to the city of Panama, a distance of 47 miles, and passes through 29 stations. The line is nearly all double track, and the Panama Railroad Company operate four passenger and two freight trains each way daily. The time required to cross the Isthmus on the railroad is about two and one-half hours on account of the numerous stops.

The Isthmian Canal Commission also use the Panama railroad considerably for hauling train loads of excavated material from the canal to the various dumping grounds and dams.

The completion of the canal will necessitate the abandonment of the present roadbed of the Panama railroad because a considerable portion of it will be submerged when Gatun lake forms. A relocated line is now well under construction which will have a grade line high enough to keep above the water in the lake, and will be entirely on the east side of the canal. It will involve the excavation of 1,600,000 cubic yards, and the embankment of 12,000,000 cubic yards of material. Excavations from the canal are being used in the embankment of the new line.

A cold storage plant is operated at Cristobal, where ice is manufactured and provisions brought down from the north are stored ready to be shipped to the various commissaries along the line.

Construction and Engineering.

In order to utilize the services of the enginer members of the commission, the work has been subdivided into departments, each in charge of a member of the commission as follows: Department of excavation and dredging, department of lock and dam construction, department of municipal engineering, motive power and machinery, and building construction.

The department of excavation and dredging embraces the Culebra division, extending from the Chagres to Pedro Miguel, the Chagres division, which includes the work between deep water in Gatun lake and the Chagres, the Colon dredging division, extending from Gatun to deep water in the Atlantic, and the La Boca dredging division, taking in all the excavation between the Miraflores locks and deep water of the Pacific.

The department of locks and dams embraces the Gatun locks and dam, the locks and dam at Pedro Miguel, the locks and dam at Miraflores, meterology and river hydraulics.

The division of municipal engineering has charge of the paving of streets, construction of waterworks, sewer systems, roadmaking, grading and other work of similar nature on the Canal Zone. Both Colon and Panama have been paved and equipped with a good waterworks and sewer system. Improvements have also been made at many other places.

Under the division of motive power and machinery comes the erection and maintenance of all the machinery used on the canal construction, the installation and operation of the air-compressor plants, the work in connection with electrical installations, and manufacture and repair work. About 2,500 men are employed in this division.

The work of the building construction division consists in the construction of buildings for the different departments and divisions of the commission. A total of 767 new buildings, consisting of quarters, offices, schools, commissaries, storehouses, shops, and etc., have been built by this department which, together with the buildings of the French Canal Company, makes a total of about 3,000 buildings of all classes.

Division of Material and Supplies.

Under this division all the supplies used by the Isthmian Canal Commission are handled. During the last fiscal year, ending June 30, 1907, this department received 37 full cargoes of material, and part cargoes from about 150 ships. Among other items handled there were 23,300,000 feet of lumber, 254,000 cross ties, 4,000 piles and about 50,000 tons of miscellaneous cargo. The storehouses carry a six-months' stock of supplies constantly on hand.

A printing plant at Ancon, under this division, operates 14 printing presses and a bookbinding department.

The land transportation on the Isthmus is also under this division, consisting of about 600 horses and mules, with the

necessary wagons, carts, carriages, ambulances and other equipment. Twelve corrals are located at different points across the Isthmus.

The general offices of this division are located at Cristobal, an office in Panama and nine storehouses at various points along the line.

Department of Labor, Quarters and Subsistence.

This department is charged with securing all skilled and unskilled labor. It assigns living quarters to the employes according to their standing as gauged by salary. It also operates hotels, messes and kitchens for the different grades of employes. The hotels are for white Americans, the messes for European laborers, and the kitchens for the natives of the West Indies. During a single month these boarding houses serve nearly a million meals.

Sanitation.

The sanitary department has made wonderful progress on the Isthmus. A great amount of work has been done to protect the employes from the malarial mosquito. This is accomplished by draining and clearing the land, and spreading mosquito oil in the swamps. Yellow fever is eliminated from the Canal Zone and a quarantine officer boards every ship that comes into port, so there is little chance of it being brought in from some foreign port.

The Department of Civil Administration.

This department was first organized by the Canal Commission, September, 1904, as "The government of the Canal Zone." Its functions were to exercise the judicial and executive rights of the government in the Canal Zone acquired by the United States under the treaty with Panama.

Although the department has undergone several changes since its original organization, it still remains in fact what it was then in name. Its duties are the enforcement of law, the maintenance of order, and "the protection of the inhabitants of the zone in their persons and property, and in their private rights and relations." It is a department of the Canal Commission coördinate with other departments, and cöoperating with them for the accomplishment of the work the United States has undertaken here.

A member of the Canal Commission is now in charge of the Zone government as "head of the department of civil administration."

The department as now organized includes the executive office, the courts of the Canal Zone, the office of the prosecuting attorney, the divisions of revenues, posts, customs, lands, administration of estates, police, education, fire protection, and public works. The head of the department also represents the commission in its relations with Panama, and with foreign consuls accredited to Panama, whose jurisdiction extends to the Canal Zone.

Climate.

Temperatures on the Isthmus as low as 72° or as high as 98° are unusual. The average daily range of the thermometer is from 75° to 84°, with very little difference between the wet and dry seasons. But the atmosphere is generally quite damp, ranging in relative humidity from 80 per cent in the dry season to 87 per cent in the rainy season. These conditions are common to many tropical regions near the sea level.

The annual rainfall at Colon and the lower Chagres valley is about 140 inches, in the interior it is about 95 inches, and on the Pacific side it is about 70 inches. Nearly all of this precipitation occurs between May and January, which is called the rainy season.

Geology.

From surface outcrops, borings, and exposures made by excavation for the canal and the Panama railroad, a clear idea of the geology of the Canal Zone has been formed.

The central portion of the Isthmus along the canal line consists of rocks of igneous origin. They are the oldest rocks of the region and have been observed at the surface in the central area, between Mamei and Empire, and northeast of the city of Panama; diamond drill borings have indicated their presence also at other points, and it is believed that they underlie, at greater or less depth, the whole territory included in the Canal Zone.

To the northwest younger rocks of sedimentary origin occur, resting on the older igneous mass, and gently inclined towards the Caribbean Sea. Nearly the same conditions prevail on the Pacific side, where, in addition to the older igneous and sedimentary rocks, younger igneous rocks occur.

Dikes and large cross-cutting masses of a basaltic nature have invaded all of the older sedimentary rocks, and are believed to represent the last phase of active volcanism in the neighborhood.

THE HYDRO-ELECTRIC PLANT OF THE GREAT NORTHERN POWER COMPANY.

By Arthur C. Ringsred, '06.

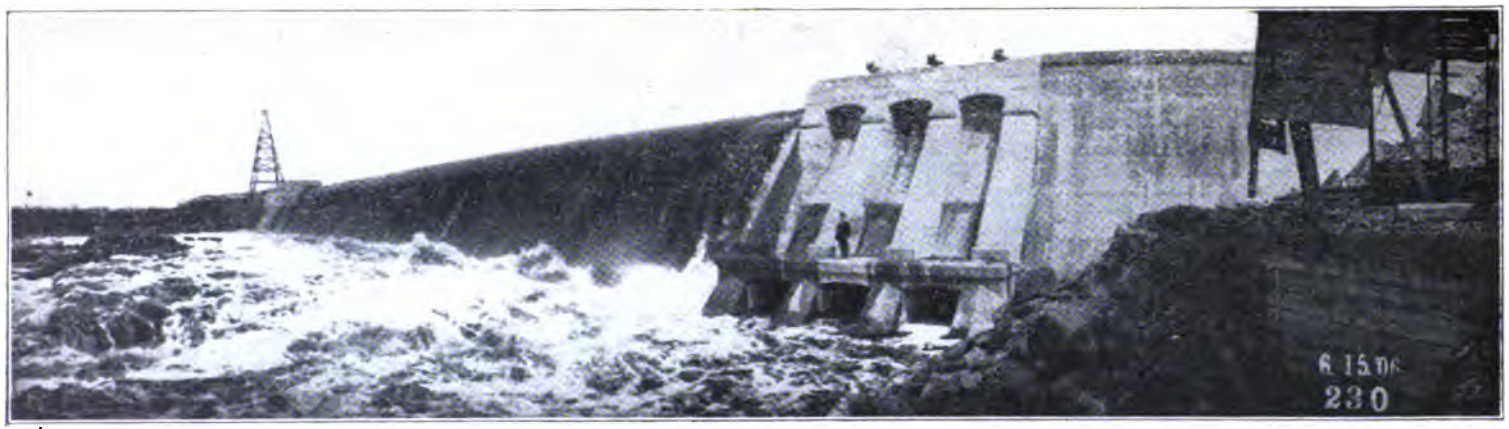
This development is situated on the St. Louis River, near Duluth, Minn., and is at present supplying power to the cities of Duluth and Superior.

The water supply is derived from the watershed of the St. Louis River with its main branches, the Cloquet and White Face rivers. The sources of these rivers are at an elevation of about 1,150 feet above the level of Lake Superior, into which the St. Louis empties. Of this total fall, 465 feet is within the last 10 miles. The total drainage area is 3,700 square miles, consisting chiefly of swamps, small hills covered with brush, and lakes.

Owing to the high head available, the construction of reservoirs is very important. The mean annual run-off is 15 inches over the entire drainage area, and reservoirs will ultimately be constructed to control 30 per cent. of this run-off, enabling the plant to be increased to 80,000 E. H. P. with a load factor of 42 per cent. A reservoir controlling 17 square mile feet of storage has already been constructed at Rice Lake.

The uppermost feature of the plant proper is the service reservoir at Thompson. This reservoir is about one and one-half miles long by one-half mile wide. It has a storage capacity of 130,000,000 cubic feet, which is sufficient to maintain operations until a supply is obtained from the storage reservoirs above. This reservoir is formed by dams, retaining walls, earth embankments, and natural slate rock ridges. The main dam of the reservoir is 1,120 feet long, while the length of the spillway is 365 feet. At one end of the spillway section are three 7- by 9-foot sluice gates, capable of drawing the water down to the bottom of the reservoir. In addition to the concrete spillway referred to above, there is a spillway 1,000 feet long formed by blasting off a natural rock ridge to the left of the dam.

The water is let out of the service reservoir into a canal by means of sluice gates, built into a small dam at the end of the reservoir nearest the station. In front of these sluice



The upper view shows the Spillway and Sluice Gates at the Main Dam. The lower cut gives a more general view of the Dam.

gates are timber racks, made of 3-inch planks placed on edge, which will intercept ice and heavy drifting material. The canal is about two miles long and is excavated through rock and earth. The earth section is made wider than the rock section, so that the velocity of the water through the former is only 2.8 feet per second, while through the latter it will be seven and a half feet per second when the requirements for water are a maximum. The canal is provided with a 200-foot concrete spillway, so that the water can never rise high enough to endanger the embankment at the lower end of the canal or forebay. The water will discharge over this spillway instead, thus preventing any further rise.

At the lower end of the canal is a 40-acre forebay, formed by an earth embankment on one side, and a natural hill and railway embankment on the other. A large amount of quicksand had to be removed in building the earth embankment in order to get down to solid material, through which water would not seep. When suitable material was reached, a timber core wall of 2-inch planks was built up, and then earth filled in. After placing the clay, the inner slope was covered with a layer or rock taken from the rock excavation. This forebay serves as a settling basin for the material brought down from the reservoir.

Built across the lower end of the forebay is a reinforced concrete sub-structure 145 feet long, upon which the gate-house is to be built. This sub-structure, which is built down into the hardpan underlying the forebay, has wing walls extending into the forebay embankment on one side and into the natural bank on the other, thus preventing seepage around the ends. The water from the forebay enters the rack chamber of this sub-structure through eight submerged arch openings. In this rack chamber are situated the steel racks for screening out material which cannot pass through the wheels. After passing first through the racks and then a set of gates, the water enters the wooden stave pipes. The gates have non-rising stems and are made so that they may be operated either by hand or by a motor from the power house. Provision is made for the insertion of stop logs in front of the gates in case they need repairs.

The pipe lines, of which there are three at present, are seven feet in diameter. Each pipe line is built in two sections. The upper section, which has a fall of about 150 feet, is built of California redwood staves about 3½ inches thick, bound together by ¾-inch steel bands properly spaced according to the pressures to be retained. These stave pipes

are about 4,000 feet long, and the upper ends are built into cast iron shoes embedded in the concrete sub-structure at the gate-house. The lower sections of the pipe lines are riveted steel pipes seven feet in diameter and 1,000 feet long. The fall in the lower section is about 228 feet, and the lower ends are built solidly into the foundations of the power house. Air vents at the gate-house and two automatic air valves placed on each pipe line prevent the formation of a vacuum

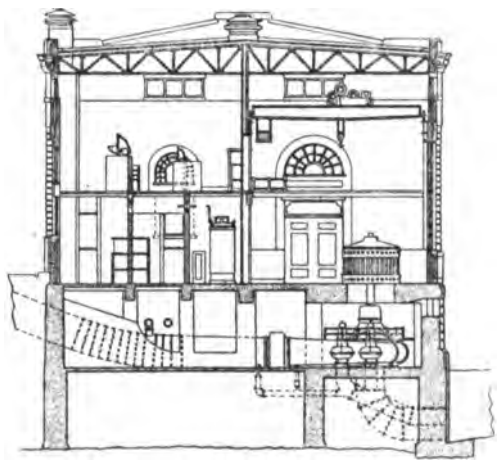
A GENERAL VIEW OF THE POWER HOUSE.

by the sudden acceleration of the water in the pipes, thus insuring them against collapse. The maximum velocity in the pipes will be 11 feet per second and the average velocity five feet per second.

Just before the last sudden drop in the steel pipes, and about 500 feet from the power house, is built a steel stand-pipe capable of holding 300,000 gallons of water. This tank is connected to a cross receiver below by means of a 6-foot

riser pipe. The cross receiver is placed horizontally across the pipe lines, and is connected to each of them by a 60-inch valve. The top of the tank is placed 23 feet above the level of the water in the forebay, and is 235 feet above its footings.

The stand pipe serves to relieve the pipe lines of any excessive pressure due to the sudden closing of the guide vanes in the water wheels when the demand for power suddenly drops. It also has capacity enough to meet any sudden demand for power up to 15,000 horsepower, until the water in the pipe line back to the forebay is sufficiently accelerated to meet the new demand. In addition the stand pipe makes it possible for the governors on the water wheels to maintain



Sectional Elevation of Power House.

better regulation and saves all the water that would go to waste through the relief valves when the load suddenly drops. Provision has been made so that in case it should be found necessary to protect the tank and riser pipe from cold, a frost box and lagging can be provided.

The power house at present is 77x181 feet in plan and 90 feet high. This permits of an installation of 40,000 horsepower, but when completed the building will be 313 feet long permitting the installation of four additional units. A generator room 38 feet wide occupies the side of the station toward the river. It is served by a 60-ton traveling crane spanning the full 38 feet. The other side of the station is occupied by the transformers and high tension bus compartments. Above these is built the gallery where the switchboard, oil switches, and low tension bus bars are situated. In the basement of

the building are the water wheels, penstocks, oil pumps and auxiliaries.

The water wheels are of the vertical shaft, pressure type, and were built by the Allis-Chalmers Co. of Milwaukee. They operate at 375 r. p. m. and were originally rated at 10,000 horsepower, but have been found able to carry 13,000 horsepower continuously, with an instantaneous overload of 18,000 horsepower. A 66-inch valve situated inside the building between the penstock and pipe line shuts the supply of water off from the wheel when it is not in operation or is being repaired. The water is led from the penstock into a spiral scroll case which in turn supplies the water to the guide vanes surrounding the wheel proper. These guide vanes may be opened or closed by two hydraulic pistons working in tandem. When the pistons move back and forth they act through a set of levers on a shifting ring which determines the amount of opening of the guide vanes, and thus the amount of water entering the wheel. One side of these pistons is connected by a pipe to the penstock which affords a constant pressure of about 158 pounds per square inch. The other side of the piston is connected to the fly-ball governor which can either supply oil to it at 350 pounds pressure or else drain it, depending upon whether the load is coming on or dropping off. Two relief valves are connected to the penstock which, in case of water hammer or excessive pressure, will open and let the water into the draft tube. One of these valves will be so set as to prevent the stand pipe from overflowing. The wheel proper is only 62 inches in diameter. The shaft is 15 inches at its smallest diameter.

The generators were built by the General Electric Co., and are 7,500 kilowatt, 3-phase, 25-cycle, 6,600-volt machines. The revolving field is mounted upon the upper part of the vertical shaft of the water wheel. The main bearing is situated between the wheel and the field of the machine. The total weight of the field, wheel and shaft is carried by a film of oil forced at a pressure of 400 pounds per square inch between the revolving and stationary rings of the bearing.

The main generators are supplied with field current from two 250-kilowatt, 8-pole, 125-volt direct current generators, direct connected to 500 horsepower vertical shaft impulse water wheels. Each of the excitors has sufficient capacity to supply the entire eight units, when installed.

There is a 3-phase, 7,500-kilowatt transformer for each generator. These transformers are the largest that have ever been built and can step the voltage up to either 30,000 or 60,

000 volts as may be desired. They are cooled by a circulating oil system, the warm oil being drawn off and cooled in a surface condenser.

The equipment is so wired that any generator may be used with any transformer, and any transformer with any outgoing line; thus any part may be repaired without putting the whole

A TYPICAL SECTION OF THE TRANSMISSION LINE.

unit out of work. Power for the auxiliary motors and for lighting the building is obtained by stepping down the voltage from 6,600 to 440.

The transmission line at present consists of one set of towers with two 3-phase circuits. The line is fourteen miles long and the towers range from 40 to 60 feet in height. The spans range from 300 to 1,000 feet in length. The conductors are No. 00 six-strand copper cables, with hemp cores, spaced six feet apart.

The sub-station at Duluth steps the voltage down to 13,000 at which pressure it is distributed overhead and underground to the coal docks, pumping stations, lighting plants and manufacturing concerns using power in Duluth and Superior. The sub-station also contains three 1,500 kilowatt motor-generator sets which furnish 600 volt direct current power for the street railway service.

The plant at present is capable of supplying 30,000 horsepower. The canal, forebay, gate houses and stand pipe are built so as to take care of this ultimate development and space has been allowed for additional pipe lines, transmission lines, and additions to the power house and sub-station.

An idea of the amount of work done may be better comprehended when it is known that 50,000 cubic yards of concrete were laid, using about 60,000 barrels of Portland cement. 300,000 cubic yards of earth and 100,000 cubic yards of rock were excavated.

Mr. F. A. Cokefair, Chief Engineer of the Great Northern Power Co., conceived the plans followed in the development of the St. Louis River, and Mr. C. C. Cokefair, President of the Great Northern Development Co., organized and financed the power company. Mr. F. O. Blackwell was chief consulting engineer.

OPPORTUNITIES FOR YOUNG TECHNICAL GRADUATES IN THE UNITED STATES.

An Accurate and Timely Discussion by Experienced Authors Residing in the East, West and South.

I.

THE EAST.

By Byron E. Smith, '07.

Whether or not the young engineer should look to the east for his first foothold will depend largely upon his individual circumstances. Probably in no part of our country will he find chances to show his mettle so numerous and diverse as in the middle and north Atlantic states. For the great steel, electric and other manufacturing centers of this section are demanding for office, shop, and laboratory an almost continual supply of technically trained men. Here in the solution of municipal and transportation problems of the first magnitude many of the finest triumphs of modern engineering are being achieved. Here every branch of his profession flourishes on a large scale, offering numberless opportunities which, were it not for attendant disadvantages, would be very attractive.

But, in the first place, the supply of men is even greater than the demand. Eastern colleges, almost without exception, maintain courses in engineering. And these courses attract even a larger percentage of the student body than in the west. Frequently the engineering department is the largest in the institution. And at two or three of the great universities the writer has been assured that fully fifty per cent of the total enrollment consists of students in the technical branches. Eastern men, moreover, seem inclined to overestimate the relative importance of the East and its opportunities. That is while the graduating class of a western college is quickly scattered to the ends of the earth, the majority of an eastern class tends to settle in the east. The natural

result is an over-supply of technical men. Their services are correspondingly cheap and conditions of employment poor.

Still, in laying his plans, the young engineer will do well not to let his judgment be too largely governed by conditions of employment in the immediate future. He should rather fix his mind's eye upon the position he hopes to occupy at the summit of his career; consider along what lines men proceed to reach such a position; and, having decided upon the general class of work to which by disposition and preparation he appears best adapted, he should strive to place himself where advancement into his chosen field should follow in the normal course of events. Now, if he is a man of some experience in the lines along which he plans to proceed, and especially if he is so fortunate as to find a suitable opening elsewhere, in the opinion of the writer, the east has little to offer him. Rather his chances of rapid advancement may be greatly improved by starting in newer territory.

There is, however, a considerable class of graduates whose technical lore consists largely of academic conceptions of the subjects involved, rather than an experimental knowledge of the same. Such a man probably has difficulty in securing desirable employment and when confronted by a serious proposition is likely to find himself handicapped by a lack of confidence in himself and his methods. With him the case is different. If he sees his own shortcomings and is endowed with a fair degree of industry and patience eastern conditions are well adapted to his needs. Certainly he must start well down the ladder. But while progress is not fast it is reasonably steady and in the course of a year or two he should find himself not only prepared to assume posts of responsibility but directly in line for advancement into any of an assortment of such positions.

This method of building a future has little of the brilliant or sensational about it. It has, however, this recommendation that the product is usually sound from the ground up. Furthermore, to a westerner, it involves seeing something of the eastern states—a valuable experience which might otherwise be indefinitely postponed.

The question thus becomes largely a personal one. Of the existence of opportunities in the Atlantic states there can be no doubt. Whether the young graduate of a western college will do better to start in here or somewhere else depends upon himself, his plans and his preparation.

II.

THE WEST.

By W. C. Weeks, '94, M. Am. Soc. C. E.

An article upon the subject of "Opportunities for Young Technical Graduates in the West" is one that requires in its consideration some cognizance of the prevailing industrial depression all over the country with its attendant curtailment of projected work, for there is no class of men who so promptly feel the effect of a tight money market as engineers. However, we all trust that this condition is merely temporary, and because of the radical difference between conditions now and in 1893, our hopes cannot seem other than well founded.

Unfortunately, the writer cannot from experience contrast opportunities in the West with those in the East, or South, as his practice has been confined almost wholly to the middle and far western states. Let me say at the outset that there is a great difference in technical graduates. By this I mean that there are those actuated by motives of expediency, by temporary environment and like trivial reasons for adopting the engineering course, and those who become engineers because of a deeply rooted love for the profession and an aptitude in its ways. To the latter class—to the sober, serious-minded young man who has his way to make and his future to build—to him and to him only, are there opportunities in the West.

There is a vast difference between opportunities and jobs. To be sure, they are intimately associated, but there are any number of jobs without opportunities. During the past several prosperous years there has been an abundance of jobs, and with them, numerous opportunities. A number of men have been able to recognize these opportunities—to make good and are now, as a reward, holding permanent positions of trust and responsibility with a bright future before them. When the time came to cut down expenses, they could not be spared. But why was this man retained and that one discharged? The chances are ten to one that it was not a difficult matter for the management to determine who should go and who should stay. An analysis of the two records would show that one was prepared and the other not, when opportunity offered.

Being prepared means many things besides having a good technical education. It means a great capacity for hard work both physical and mental, and a willingness to do it; a pains-

taking interest in and a clear understanding of the objects to be attained; a study and comparison of conditions and methods. To the young technical graduate who is thus prepared responsibility is soon given in the West, and this is the beginning of opportunity. Once this point is passed the way becomes a paved street. To him who can carry his success with becoming modesty, the future holds great possibilities.

To the writer, this early tender of responsibility is one of the distinguishing characteristics of the West. The reasons may be that institutions are younger; there are not so many men higher up to try out before the ambitious young graduate gets a chance, and there appears to be a readiness to recognize and reward ability that does not seem to obtain in like degree in the Middle West. Our institutions are much more democratic; exclusiveness is not deemed part of the business man's code. Then, too, there is a very general recognition of the necessity of an engineer for the numerous engineering undertakings in the great developments now under way.

That the development of this country has just begun is the belief of all who tarry long enough to become acquainted with the growing necessities and requirements of this splendid inland empire, as it is familiarly called. There are yet thousands of acres of rich land to reclaim from the desert with life-giving water, stored in mountain reservoirs and distributed by the irrigation ditch. Cities, towns and communities form as a result of this reclamation and they demand light, power and transportation—the work of the engineer. Railways are over-taxed—new ones—steam and electric, are building; vast river improvements are projected to relieve the railways of excessive burdens. While for the most part engineers are salaried men, an engineering training should go a long way toward fitting a man to go into business for himself—to become a contractor on his own account. Nowhere can opportunities of this kind be more numerous than in the West. Men of responsibility are more approachable, more sympathetic with the beginner and they will talk more freely here than anywhere else. The ambitious young graduate who is prepared can readily obtain a small contract on his own account with very little capital save a determination to win, and thus lay the foundation for a highly successful business career.

The winning of the West has but begun. There is room —nay, more than that, there is need of ambitious young technical graduates who are prepared. And let him who comes, come to stay, to work, to endure disappointment and even

hardship in a cheerful, optimistic spirit and turn adversity as well as success to account in the broader education that teaches us how to live. There is competition in this western land of ours, of the open and above board kind, and he who cannot compete and make good, can never rise above mediocrity. If you come to the West be sure you are prepared.

III.

THE SOUTH.

By R. J. S. Carter, '07.

In regard to the question of opportunities for technical graduates, whatever may be said of any section of our great country may in many respects be just as truly said of the South. Opportunities in the present state of our industrial development depend so largely on the man and his training that geographical location is really of secondary importance, for we all realize that the man can do more for himself than any one section of our country can do for him.

As a general thing, when graduation draws near our young friend takes a hasty inventory of prospective positions and accepts about the first thing offered, whether it be south, west or east. In this respect the engineer is more largely a creature of circumstance than any other professional man. This is especially true of electrical engineers, for the electrical business has developed into so many different lines that it is all one can do to keep posted, to say nothing of following all lines with accuracy.

By the time a man finishes college he should have a pretty good idea of himself and what particular line of work his education and general aptitude has qualified him for. If his strong point is along the theoretical, mathematical or strictly technical side of engineering, his place is with the designer rather than in the South. It is not to be inferred that there is an over-supply of such men in the South, but habit makes this part of the country draw on the New England states for the few strictly technical men now needed. This has always been their source of supply, and will continue to be just as long as the East remains our great national clearing house for brains. Another reason for this is that most Southern industries are controlled by Boston or New York men who naturally select from those around them.

As a general thing the local material for engineering work which one finds in the South is of inferior grade and the people

there seem to know it. They take it for granted that if a man is any good he would be somewhere else, so unless you are a mining engineer do not go South "prospecting." Speaking from a Western standpoint, if one desires to locate in the South, go East first and work out from there.

The man who is needed in the South is the technical man with business experience and commercial ability. In fact, this is the keynote of the whole situation, and in the writer's opinion is the only class of men really needed there.

Owing to the shortness of time in our college courses it seems necessary to leave business education to the hard knocks of the world, and perhaps that is the only place to get such education. Be that as it may, the young engineer who leaves the commercial side of his education out of consideration will get way behind the game and, sooner or later, will wake up to find that someone else has carried off the pot while he (figuratively speaking) has been studying "Steinmetz" or building air castles on the possibilities of his thesis.

There is no field that calls so loudly for technical men as the commercial side of engineering. Considering the great latent and undeveloped resources of the South there is no section of our country that offers equal possibilities to the commercially inclined engineer.

Investigation will show that the South is very well adapted to many manufacturing enterprises. Iron and coal are there in abundance, as is also a very high grade of clay for high tension insulators. There is considerable water power, and during recent years great development has been made in phosphate mining. There are great beds of natural prosphate fertilizer simply waiting for the promoter and engineer. The Northern engineer who knows what it is to work, and who is immune from the Southern "tired feeling," will here find the possibilities for a lucrative future.

Of course we do not presume that a young technical man fresh from college could bring about great industrial developments in the South, or in fact anywhere, until he has had considerable experience; if, however, one is industrially and commercially inclined, the South offers a great future to him who will go there and "grow up with the country."

HYDRO-ELECTRIC DEVELOPMENT IN COLORADO.

By Lewis E. Ashbaugh, '00.

The development of water powers in the Rocky Mountains presents some interesting problems, some of the details being very different from the developments in the Mississippi valley and the Eastern States. The engineers at "Minnesota" studying within sight of the several power plants at St. Anthony Falls, may appreciate a report on Colorado conditions and problems.

As Colorado occupies the crest of the continent, the streams rise within its borders and flow in the various directions from comparatively small watersheds. The streams of the eastern slope emerge from the mountains onto the plains with small volume, but their great fall permits some interesting developments, while the Grand river, of the western slope, gathers the waters from tributaries to such an extent that a fall of one hundred feet through a canon may be profitable to develop. On the eastern slope of Pike's Peak, within view of Colorado Springs, a nineteen-inch pipe line carries the water from a very limited watershed and delivers it to a power house at Manitou, near the cogwheel depot, under a head of 2,300 feet, and generating 3,000 horsepower. In the vicinity of Boulder, just north of Denver, the continental divide with elevations over 14,000 feet approaches within 20 miles of the plains to the east, at 6,000 feet elevation, again emphasizing great fall and small watershed.

The large use of the waters of the eastern slope for irrigation, and the early priorities giving ownership of these waters, renders difficult the utilization of some of the best streams for power purposes. The stream gaugings have, in the past, been largely made in order to secure information for irrigation requirements. Little record has been made of the winter flow. The streams discharge the larger part of their total annual flow during the summer months, the maximum flow usually occurring about the middle of June. This is the time of year when the irrigation needs are also at a maximum. During the winter the flow decreases so that power development using the low discharge would be impracticable. Storage reservoirs are therefore necessary to regulate and equalize the

flow, and these must be located up in the mountains above the proposed intakes. If the summer flow is not fully appropriated and beneficially used for irrigation, there may be enough water to supply both the power plant and the irrigation interests, assuming that the power development does not include reservoirs sufficient to store all the discharge waters.

The order of procedure for using the stream discharge for power purposes is to store, during the summer months, all surplus water for which reservoirs may be found, using such part of the natural flow as may be required to operate the plant. As the discharge diminishes in the fall, stored water must be released to supply the plant; and such must continue until spring. A stream which discharges over 500 second-feet during all of June may dwindle to less than 5 second-feet during January, with an average of 70 second-feet during the whole year. The total discharge may exceed 50,000 acre-feet during June and July, and be less than 1,000-acre feet during two or three winter months. With sufficient reservoir capacity in the headwaters, and with no irrigation rights to demand more than 70 second-feet, a development could be made to use the 70 second-feet average flow, less evaporation and other small losses. But a single year's condition is not sufficient. A series of years must be considered and the minimum possible flow taken as the only basis which will be satisfactory to the investing financiers and to purchasers of power. Again, the small reservoir capacity available may permit a regulation to only a small portion of the average for the year. If irrigation rights must be satisfied, it may be necessary to construct other reservoirs below the plant and above the irrigated fields, giving secondary storage, such that the regulated flow may be discharged into such reservoirs during the winter season and thus be available for use on the fields during the summer.

The determination of the regulated discharge of the stream is an interesting problem, dependent on many factors, such as total discharge of the year and distribution thereof, storage available, irrigation requirements, etc. The records of gaugings as made by the hydrographer are of great interest. The "Water Supply and Irrigation Papers" of the U. S. Geological Survey are in constant use. On large developments the company employs a hydrographer to make special investigations. Automatic register gauges are used on streams where detail data are required. Co-operative work with the U. S. Geological Survey is undertaken to the advantage of both parties.

Illustrative of the variable flow of mountain streams, a page of gauge register curves (combined from as many sheets) is

shown. Curves 1, 2 and 4 are from a station ("A") up close to the continental divide, with its snowy peaks, above which station the drainage area is about 30 square miles. Curves 3, 5 and 6 are from a station ("B") on the same stream, but down near the plains, 13 miles from "A," with drainage area about 100 square miles. These curves show gauge heights for one week each. Coincident in time are curves 2 and 3, also 4 and 5.

These curves are interesting in showing the large daily variations and also the decrease from summer to winter discharge, though neither the maximum summer nor minimum winter flow can be shown, as record sheets are not available. For the week shown by curve 1, it is noted that on Sunday evening at 8 o'clock the discharge was 348 second-feet. At 2 o'clock on Monday afternoon the discharge was 233 second-feet, and at 1 o'clock on Wednesday it was only 210 second-feet. On Friday evening it had increased to 353 second-feet. The peak discharges occurred between 8 and 10 p. m. with low discharges soon after noon. During June the peaks occurred at about 5 p. m., while curve 5, for station "B," shows the November peaks at 2 to 4 a. m., and curve 6 shows December peaks at near noon of the following day. During June the snow line is down close to the stream, and the daily "high tide" or peak occurs soon after the sun has melted the snow, while later in the season the remaining snow is farther up on the mountains and melts in less volume, thus requiring a longer time for the tide to travel down the valley to the gauging station.

These curves show the value of automatic registers and continuous records. A single current meter gauging, taken during the week represented by curve 1, might be made at noon and get a very different result from the true average. The U. S. Geological Survey gauges are read by resident observers morning and evening, thus tending to get an average result for the day. Current meter gaugings are then frequently made and corresponding gauge heights read, thus giving the rating table for estimating discharges for all gauge readings at the given station.

Curves 2 and 3, for October, show how the summer flow has decreased and the daily tide become less pronounced. If curve 3 is shifted back 6 hours (shown by dotted lines) to allow for the distance between stations "A" and "B," the coincidence of maxima and minima becomes remarkable. The daily fluctuation is still large on some days. Curve 4 was taken when anchor ice was forming and causing fluctuations

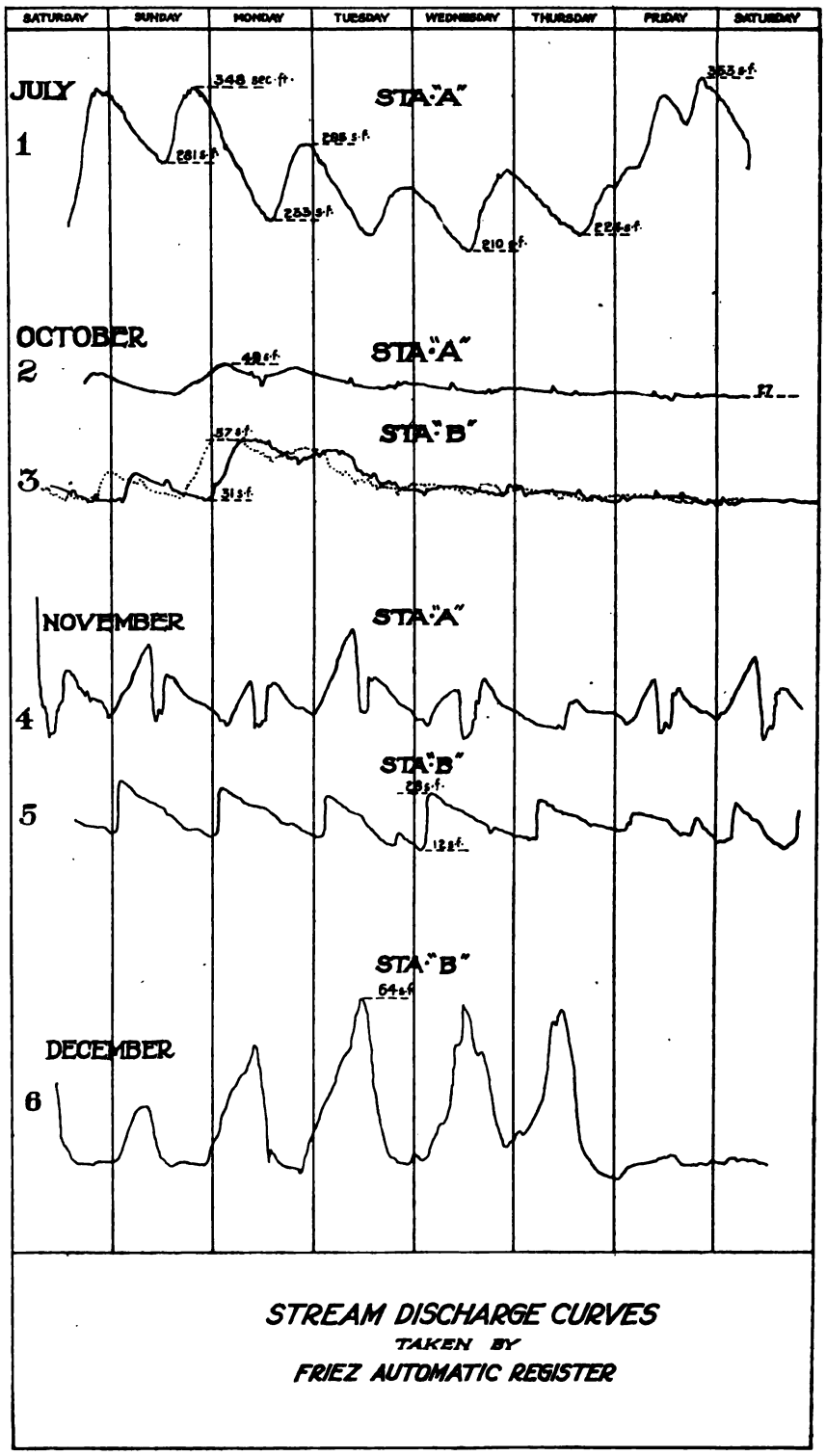

SATURDAY
SUNDAY
MONDAY
TUESDAY
WEDNESDAY
THURSDAY
FRIDAY
SATURDAY
JULY
1
STA."A"
348 sec.ft.
281 c.f.
285 c.f.
233 c.f.
210 c.f.
226 c.f.
353 c.f.
OCTOBER
2
STA."A"
48 c.f.
37
3
STA."B"
57 c.f.
31 c.f.
NOVEMBER
4
STA."A"
5
STA."B"
28 c.f.
13 c.f.
DECEMBER
6
STA."B"
64 c.f.
STREAM DISCHARGE CURVES
TAKEN BY
FRIEZ AUTOMATIC REGISTER

FIG. I

in the channel, but curve 5, taken the same week at the lower station, shows pronounced and regular tide variations, at one time changing from 12 to 28 second feet discharge in two hours. Curve 6 shows the effect of cold December weather. The variation is intensified in the record by the ice formations.

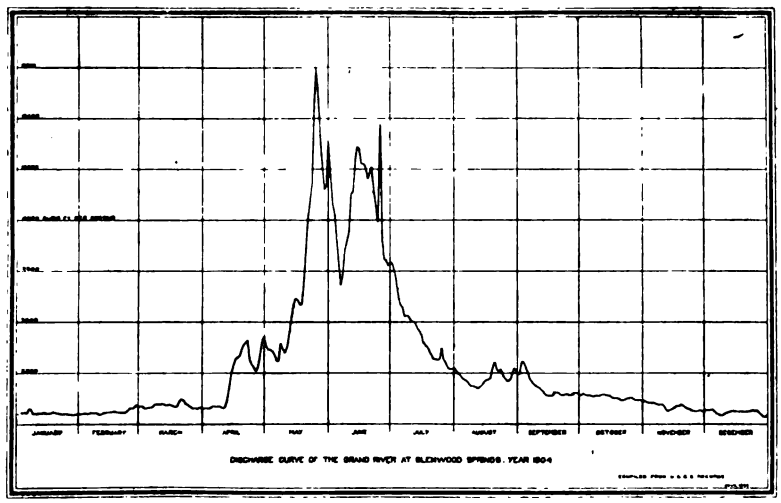


FIG. 2

The annual record of a Colorado stream is shown by the "Discharge curve of the Grand river at Glenwood Springs, year 1904" (Fig. 2). During six winter months the discharge was less than 1,250 second feet, while for three months it exceeded 3,000, and at one time reached 17,500 second feet. In 1899 the maximum discharge reached 29,000 second feet.

In the Eastern States much is said about the relation of run-off to rainfall, and the run-off per square mile. On some watersheds of the Rocky Mountains, the rainfall records show less precipitation than the run-off of the streams, due to their being much greater precipitation around the peaks than in the park and valley areas in lower altitudes where the towns are located and meteorological stations established. The effect of high altitude and proximity to snowy peaks is shown in comparative data obtained on two watersheds of nearly equal area, about 25 square miles, separated by about five miles between borders, the one "fronting" for several miles on the Continental Divide, while the other does not quite reach up to the divide and then with a pointed end, as compared with the broad "front" of the first. The July, 1907, records show run-offs as follows: 11.25 second feet per square mile for the first watershed, and only 1.00 for the second.

The watershed which includes both of the areas just treated, together with an additional intermediate and tributary area of about equal size shows a run-off of 4.26 second feet per square mile for the same period.

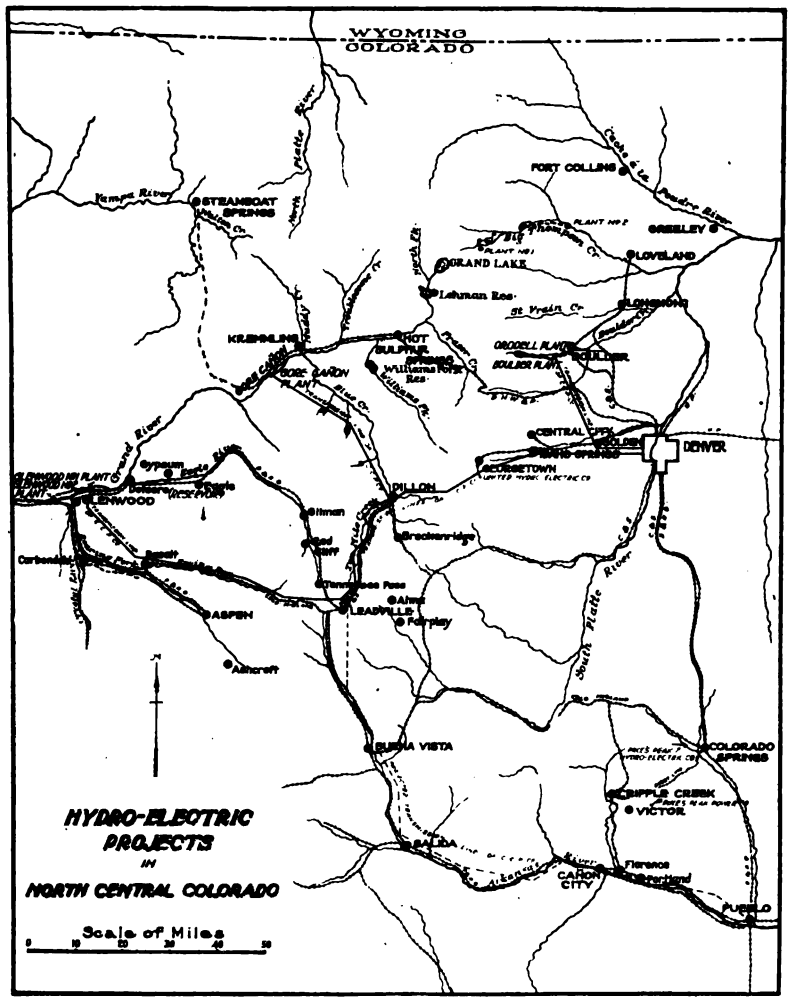
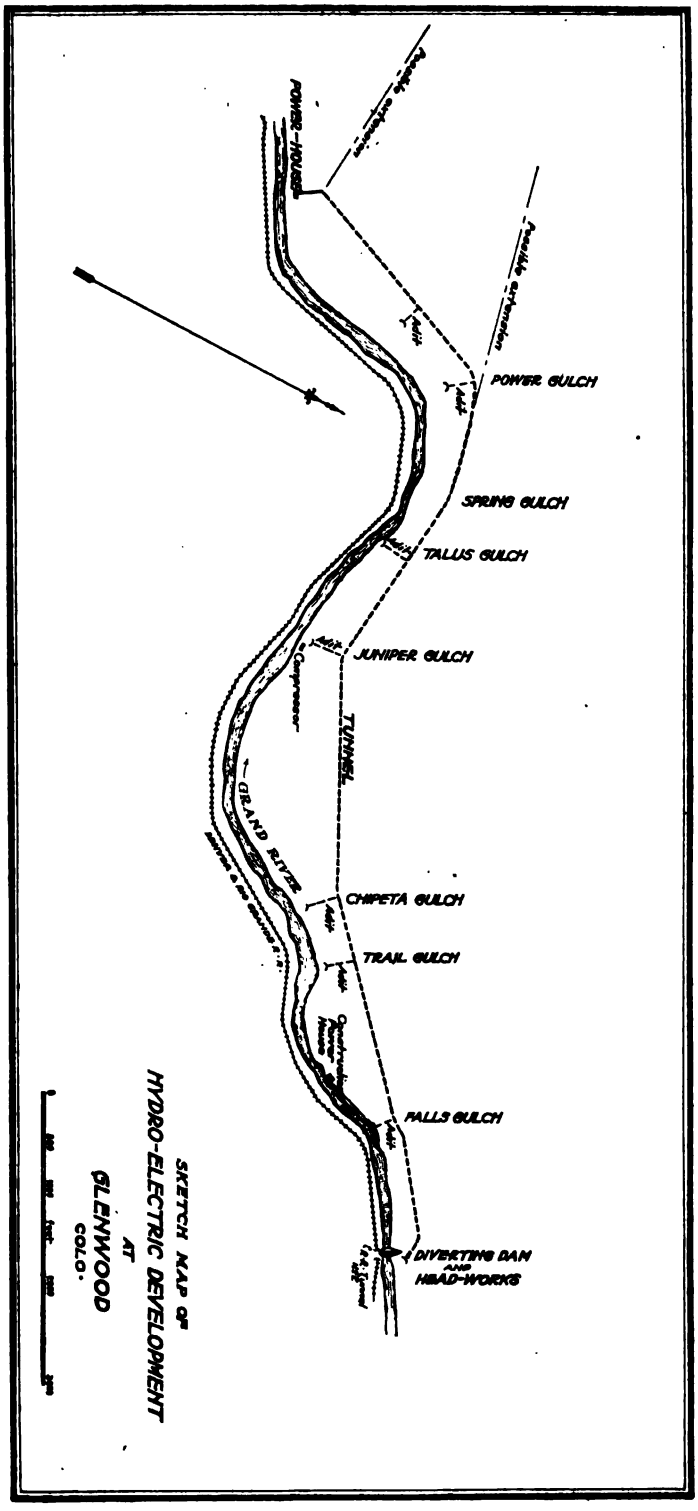


FIG. 3

Considerable attention has here been given to hydrography, because the water supply is the first essential, and Colorado mountain conditions are so very different from those of the Eastern States and the Mississippi Valley.

The Central Colorado Power Company is planning some extensive developments, three of which are in process of construction, namely: plants at Boulder, Gore Canon and Glenwood. Investigations and filings have been made on several

Fig. 4.


POWER-HOUSE
POWER GULCH
SPRING GULCH
TALUS GULCH
JUNIPER GULCH
TUNNEL
GRAND RIVER
CHIPETA GULCH
TRAIL GULCH
FALLS GULCH
DIVERTING DAM AND HEAD-WORKS
SKETCH MAP OF HYDRO-ELECTRIC DEVELOPMENT AT GLENWOOD COLO.

other projects, among them being, Big Thompson and Roaring Fork. While plans are not definitely determined and continued studies are revealing new methods and possibilities brief general descriptions and explanations will be made of the Glenwood and Boulder projects. Sketch maps of these projects and of a portion of the state are given for reference.

By means of such reservoirs as Grand Lake, Lehman and Williams Fork Reservoir, it is planned to regulate the flow of the Grand river to 1,000 second feet at Gore Canon and 1,250 second feet at Glenwood. These are to be "base load plants," to generate electricity at a continuous maximum rate. The fall or head at Gore Canon is about 300 feet, or, with a proposed extension, about 400 feet. The development is very similar to "Glenwood." Any reservoirs above Gore Canon do double duty in regulating the flow for the two plants, and it is possible that they will become still more valuable by the development of other powers on the Grand river both above and below Glenwood.

The Glenwood delevopment is located in the beautiful canon just above the city, along the D. & R. G. R. R. The intake is near the railroad tunnel "No. 2," so often illustrated in advertising matter and on postal cards. A diverting dam with flashboards or needles will form a pool and divert the water into the tunnel, which is now being constructed. The waterway will be about 16 feet wide and 10.5 feet deep, with grade of 2.64 feet per mile, to carry 1,250 second feet. The length of tunnels will be about 12,000 feet. Two steel pressure pipes will take water from the tunnel forebay to the two turbine wheels and generators. The net head is about 165 feet, thus giving about 16,500 electrical horsepower. As first planned, the present development would have only 9,000 feet of tunnel, with 140 feet head, and would look forward to an extension toward and perhaps beyond the city of Glenwood, giving much increase in power. The tunnels are being bored through hard granite, requiring very little timbering and arch lining. The sides and bottom will be concreted and smoothly finished.

The Boulder plant is designed to carry the peak loads for the other base load plants. Such reservoirs as Barker and Nederland will store the summer floods for winter use. A 36-inch concrete pipe line about 12 miles long follows along the hills at constant grade, cutting through some projecting ridges by tunnels and crossing deep ravines by inverted steel siphons, carrying a constant supply of water from Barker Reservoir to Kossler Reservoir. This pipe is a gravity water-

way and will carry about 54 second feet at a maximum. This quantity is quite different from Grand River conditions. Kossler reservoir is a terminal reservoir, receiving a continual supply from Barker Reservoir, and transmitting to the powerhouse as required by means of a steel pressure pipe over 9,000 feet long, 56 inches diameter by one-quarter inch thick at the upper end, and 44 inches by 1¼ inches at the lower end, where the head is 1,845 feet. During the late afternoon and the evening, and at other times of peak load, this heavy steel pipe will deliver to the powerhouse the water which the gravity pipe line has been supplying to the terminal reservoir during the 24 hours. This terminal reservoir gives the value to this development. Two impulse wheels of the Pelton or Boble type will be used, the capacity of each being 9,000 horsepower. Other interesting features of the Boulder development are the big reservoir dams, a 165-foot masonry dam being planned for Barker, and one or two large earth dams for Nederland. Another development is possible by taking the water from the powerhouse and conducting same by tunnels and pipe lines to the edge of the foothills, on the west side of the city of Boulder, a distance of about three miles and affording a fall of about 400 feet.

The main transmission line will extend from Glenwood to Denver, passing through the large mining camps at Leadville, Breckenridge, Dillon, Georgetown and Idaho Springs. To this line will be connected the lines from Gore Canon and Boulder. Branch lines will supply the manufacturing district at Pueblo and the great mining camp at Cripple Creek.

THE FIVE-YEAR COURSE OF STUDY.

By Frederick S. Jones,
Dean of the College of Engineering.

The establishment of a five-year course of study in the College of Engineering at the University of Minnesota marks a turning point in the history of technical education in the Middle West. For twenty years the curriculum has been in a process of readjustment made necessary by the growing demands of modern practice. Rapid development in every line of engineering science has compelled the introduction of a great variety of purely technical subjects at the expense of those studies which are commonly called cultural and which are generally admitted to be essential factors in a liberal education, such as engineering education should aim to be.

An examination of the prescribed curriculum as administered up to the present time shows that of the ninety-two credits required for graduation, eighty-six must be gained in technical studies, or those prerequisite to, and bearing directly upon the purely technical subjects, while but six credits are devoted to cultural studies. Recent graduates have been given no opportunity to study any foreign language, history, logic, philosophy or political economy. Four hours devoted to rhetoric for a single year and required of all freshmen with a view to drilling them in the art of writing simple English, and two hours devoted to the subject of political science in order that the student may know the fundamental principles of our system of government, represent the sum total of purely cultural work included in the curriculum, as it has been until now. This condition of affairs is not peculiar to Minnesota but is found to exist, to some extent at least, in almost every engineering school in the United States.

The demand for men of technical training has been such and the pecuniary inducements so great, that students have hastened to avail themselves of every opportunity offered to prepare for service in the several engineering professions. The graduating classes have increased in size and the men have found remunerative employment awaiting them upon

the completion of their college course. What wonder then that the technical education now offered has been deemed highly satisfactory, or that the engineering courses have been extolled as practical and sensible, teaching boys to do things as well as to know things, and making them useful and productive factors in our great industrial system.

But the scale by which we measure the value of an engineer's preparation for life should be ruled on both sides. One reading on this scale should indicate the efficiency of the graduate as an engineer, the other should measure his value as a citizen and a man. Heretofore, the result of our courses of study has been expressed in terms of technical efficiency only, but there is a growing demand for something broader and better.

In the words of President Schurman: "The modern engineer, if he is to be truly educated, needs a training broader than physical science and technical study. He too, because he is a man, needs the culture of the humanities—that liberalizing and expansion of mind which comes from the study of literature, history and philosophy. This, however, he can no longer secure in a four-years' technical course. The result is that all over the country men are graduating in the engineering courses with an ignorance of literature, history, and the other liberal arts so dense that no proficiency in science and technology can save them from the charge of being uncultured, especially, when, as so often happens, as a necessary result of their limited reading of literature, they are unable to express themselves, either in speech or writing, in correct English prose."

The requirement of two years of academic work as a proper standard for admission to any professional school has been proposed by the Association of American Universities. While it has been deemed unwise to adopt this proposal at the present time, the Faculty of the Engineering College and the Regents of the University have agreed that the extension of the course to five years is both feasible and desirable. Such an increase in time permits the introduction of a full year of work in language, history, philosophy and economics which justifies the college in conferring of the B. S. degree as will be done at the end of the fourth year, inasmuch as it has been determined that no additional technical work shall be injected into the new course but that the year added shall be devoted exclusively to such studies as tend to liberalize the education of the prospective engineer. The work of the five years has been so distributed as to compel the student desir-

ing the engineer's degree to complete the entire course, the first two years being cultural and the last three being increasingly technical in character.

Critics of the proposed change call attention to the fact that five-year courses are by no means unknown but do actually exist at the present time in various engineering colleges and that our own course of science and technology has been offered to students for many years. It should be remembered, however, that such courses have always been offered parallel to four-year courses in engineering and therefore have never proved attractive to students. Candidates for the degree of engineer are human and it is the exceptional student who will choose a five-year course when, by taking a four-year course, he can get all of those studies which seem to him to be most essential for his future work.

The new course has been arranged with this fact clearly in mind and the studies which to the student's mind seem absolutely indispensable to his success as an engineer are placed in the fifth year of the course. This is a very different arrangement from that in vogue in most of our technical institutions, for it is almost the universal custom to offer the technical studies in the fourth year, thereby precluding the possibility of any considerable number of students choosing an additional year.

Educators in the different engineering schools when consulted as to the desirability of the proposed course have all conceded its advantages and the need for it, but few are willing to admit that it is feasible. The chief objection offered is that no one school can afford to insist upon such a course unless its near competitors do so, for the reason that the institution having the highest standard would find its students departing to neighboring institutions requiring less work for the desired degree.

It is believed that Minnesota, because of her unique position, may find it possible to require five years of study as necessary for the engineer's degree. The large territory from which she draws her students and the great distance to her nearest competitor, as well as the relatively small fees charged in her undergraduate departments, combine to make this institution an ideal one in which to introduce and develop the higher standard. A considerable reduction in attendance is to be expected for a few years, but the faculty is consoled by the thought that the finished product will be much better in character.

It is also believed that many students now entering upon an engineering course and finding themselves disinclined to continue it to its consummation, will enter upon some non-technical vocation, after they have received the Bachelor's degree at the end of the first four years of their college work, having acquired an excellent training and being well fitted for the duties of citizenship. It is by no means improbable that the four years of the kind of general training offered will attract enough students to make up in large measure for the losses resulting from the increased length of the technical course.

A reduction in the enrollment would not be an unmitigated evil. The number of students in the college at the present time is too large in proportion to the number of instructors, and a reduction in the enrollment will obviate the necessity of an immediate increase in the teaching staff. Smaller classes will result in better work and while fewer students may graduate, they will be better engineers and more important still, better men. However, it should be understood that the new course has been established, not with any desire to reduce the number of students registering in the college but solely with the hope of humanizing the education offered and rendering it adequate to meet the requirements of a broader and higher standard of attainment.

TECHNICAL JOURNALISM.

By A. D. Williams, Jr.

Technical or trade journalism offers an interesting field for the technically trained man and there are several branches of this line of work which can be followed with profit. There are, however, two qualifications necessary for success in engineering journalism: the faculty of close and accurate observation, and the ability to express thoughts in good, clear, concise English. These two qualifications can be developed by practice. The ability to use good English is comparatively rare, but it can be cultivated by careful criticism of one's own work, either by others or by the writer, and by immediate reference to the dictionary to settle the slightest doubt in regard to the fitness of a word for the position assigned to it. Observation can be cultivated by the endeavor to remember things which are seen and heard, and then checking the success of your trial by a second visit, noting the omitted points. Observation is here used in its broad sense as covering all the perceptions of the senses, including the journalistic instinct for knowledge of news. The knowledge of what constitutes a good news story is an extremely valuable asset and will be of great assistance, it implies a wide and up-to-date acquaintance with the field covered, which can only be obtained from the news and advertising pages of the technical press. In fact, it may be said that the man going in for technical journalism has to study all of the time.

One of the greatest handicaps that besets the aspirant for literary honors is a lack of knowledge of the simple rules of English composition. Apparently but little effort is bestowed upon the study of English, in any of the graded schools, preparatory schools, technical schools and colleges. The signs of this are visible in the correspondence of technical firms, even their highest officials failing in the effort to turn out a decent English sentence. In technical papers the same signals show an appalling ignorance of the language spoken daily by the various contributors. It certainly seems as though the importance of accurate expression in words would warrant much greater care than is bestowed upon it in the

average course of study. A carelessly worded contract or specification may cause an immense amount of trouble and expense and the same may apply to a letter which is loosely worded. In fact, the daily conversation of business and technical men abounds in loose expressions, good English being exceptionally rare. A knowledge of one's own language is really as essential as a knowledge of mathematics and it is time that our schools and colleges awoke to their slackness and insisted upon their students acquiring a working knowledge of English composition in place of a superficial knowledge of the rudiments of grammar.

The available openings in this field lie in several directions: the free-lance writer, the editorial writer, the special correspondent, advertising writer, and publicity work all afford legitimate openings, many of which afford a better financial return than regular engineering work. The free-lance, as the name implies, is not regularly connected with any paper or other concern, and is practically his own master and, provided he can turn out acceptable stories in first-class shape, the amount that can be earned at space rates depends entirely upon the industry of the man himself. His field is not limited to that of the trade press as there is a constant market for industrial stories in the magazines, weeklies and newspapers; this field, however, requires the ability to handle the subject in a "popular" manner so that it will not be 'way over the heads of ordinary readers. To the free-lance everything is a story for one paper or another and the larger the field he can cover the better his returns. In some cases he will be able to arrange in advance for his stories, but in the majority of cases he writes upon the chance of having the matter accepted, and the chances of acceptance will be increased when he arranges his matter so that it can be handled with the smallest amount of trouble in the editorial office. Typewritten matter is preferable to hand-written, but if the idea is worth presenting it will be accepted in almost any sort of shape and worked up in the office of the paper. In fact, there is a certain amount of difficulty in securing good material, so much so that some of the papers are ready to send men out to work up the kind of stories they want, even when such a story involves valuable publicity features to the firm whose methods or products are treated upon.

Editing a paper is not one continual dream of bliss. The paper must go to press so that it will issue promptly upon the day of publication. Sufficient matter must be got ready for each issue and prepared for the compositor; in addition there

are the cuts to be looked after. The editor must be on his guard all of the time, each article must be weighed and its merits decided upon, as to whether it will interest the readers or not. The sensitive feelings of advertisers must be borne in mind, as well as those of readers and other concerns. Each editor must also be able to sense the writer's intent and by reading between the lines gather from the story submitted an idea of the ability and knowledge of the writer concerning the particular subject treated. He must look out for syndicated stories, that is, stories submitted in duplicate to several different papers. The writer who syndicates his matter speedily becomes known in an unfavorable manner and editors become very chary in regard to the acceptance of his manuscript. There are other editorial duties too numerous to catalogue in the space of this article.

The technical graduate who desires to qualify for editorial duties must of necessity acquire a certain amount of practical experience in the varied lines of engineering work and the broader and the wider his experience the better he is qualified for the editorial chair. It is only by this practical working acquaintance with the work that he can place himself in the position of the man on the job and whip the articles which are submitted to him into proper shape. It is also necessary for the editor to travel about and keep in touch with the work in his field. as it is only in this manner that he will be able to retain that intimate acquaintance with methods of work which is necessary if he desires to attain his fullest usefulness.

The special or editorial correspondent may be upon a salary or space rate, and located in some territory which the paper desires to cover thoroughly by a personal representative. This sort of a connection has certain advantages to a free-lance writer. For instance, he may be able to arrange with several papers on non-competitive lines to submit all of his matter in their field which he produces to them, and in case they do not use it he is free to send it elsewhere; in addition the papers will inform him in regard to possible stories in his neighborhood so that he can work them up for them. From the writer's standpoint an advantage of an arrangement of this kind arises from the added facilities he gains for acquiring information which can be worked up into stories, since he has the prestige of the paper to assist him.

The advertising writer has a wide field and requires an intimate knowledge of typography and human nature. His work may range from the preparation of display advertise-

ments in the papers to the composition of advertising publications. Large concerns usually employ men for this work while the smaller firms have it done by men who make this work a specialty. In addition to a knowledge of type and paper, the ideas of the selling force must be taken into consideration. This writing goes out at the expense of those in whose interests it is prepared and in many cases is difficult to handle. The engineering facts presented must agree with those of the engineering department; the selling arguments must be approved by the sales office; and the matter must be presented in such a manner that it will attract the attention of possible purchasers.

Publicity work differs from advertising in that the matter prepared is intended for use in the news columns or in the special portion of the paper devoted to industrial items. Exclusive stories and good stories get into print, but unless this work is well done a large portion of it reaches the editorial waste basket. This matter is sent out to keep the public acquainted in detail with new or interesting work produced. Many papers read before the engineering societies can be really placed in this class, even though they present facts of engineering value and interest. In fact, many concerns encourage their engineers to present such papers and articles to the societies and to the press owing to the indirect advertising value of such matter. The fact is there are very few articles which appear in the trade papers that do not possess publicity value for one or more concerns, or for their writer.

As to whether writing pays for the individual or not, there is really more than the actual cash return to be considered in most cases. The man who writes gains facility of expression; he learns the exact words required to express his meaning; he learns to arrange his subject in a logical manner and to present his arguments for or against in such a manner that they possess force. This last is of a different order from a forcible manner, since a forcible manner is often entirely lacking in force. The writer becomes known to a wider and wider circle of men, and this is an asset either to the salesman or the engineer. The fact of his name being known through his writings serves in many cases as well as a letter of introduction. The man who uses a pen name or whose matter appears unsigned, of course misses some of these benefits, but on the other hand he occasionally has the pleasure of finding out how it feels to have his work caustically criticised to his face, in a manner which would not occur were his identity known. In addition the nom du plume has certain advantages

in many cases, as for instance, when it would be impolitic for the writer to reveal his real identity. Such cases often occur. Opinions expressed in print are much harder to dodge than oral ones; they do not die although their death is often devoutly wished for, and occasionally one's confreres endeavor to get one into arguments of a more vigorous nature that those conducted with the pen. But when all things are considered there are disadvantages to all other lines of endeavor.

One of the advantages of technical journalism is the ease with which a start can be made. The editors are looking for good material all of the time, and if you can supply matter of the character they require it will be found a comparatively easy matter to get into print. However, it will not do to be discouraged should more or less of your manuscript come back; all authors have had this trouble to a greater or less extent; and it will often be found that what is unsuitable for one paper will be gladly accepted by another. In many cases a great deal of writing can be done in one's spare time which will often prove more profitable than going out for the evening. Do not be in a hurry to send your story away, let it lay for a while and when you go over it you will often be surprised to find out how many changes are desirable. It is also a good plan to keep a copy of your manuscript and compare it with the story as it appears in print. You will often be surprised to find out what the editor has done to it and how ruthlessly he has trimmed it. But such lessons will prove a salutary check to your pride upon the first appearance of your work in print. The writer has a vivid recollection of the first item of his that was printed, though many of the intermediate efforts have escaped him.

On the whole, writing pays a little more than the average, but as has been stated, the reward reaped is dependent entirely upon the individual and the amount of study and effort concentrated upon the work. Each individual has a style of his own and while there are many good models to follow, it is best to use the simplest language, and the fewest and shortest words which will convey the meaning desired. Abstruse mathematical arguments and polysyllable Greek and Latin derivatives are usually skipped by the reader.

INDUSTRIAL CONDITIONS IN NEW ZEALAND.

By J. J. Flather.

Professor of Mechanical Engineering.

This article is the result of the personal experience and observation of Prof. Flather, who made an extensive tour of New Zealand during the summer of 1907.—The Editors.

Australia and New Zealand are both delightful and interesting countries. In New Zealand, particularly, I was constantly surprised with the marvelous beauty and variety of the scenery. It is without doubt the most wonderful scenic country in the world. Its snow-clad mountains, beautiful lakes and waterfalls in the south, and its awe-inspiring geysers and volcanoes in the north, are unrivalled; but of still greater interest are the people and their institutions.

The people, with the exception of the native Maoris, are essentially English, but there are large numbers of Scotch and Irish who have settled in certain portions and united with the English. The result has been the development of a fine and vigorous race, shrewd, resourceful and industrious, but obstinate, yet withal, honest.

The settled portions of the country remind one of England and English life. The gardens are filled with English fruits and flowers, the cattle have been imported from the home land, even the grasses are from English seeds, and the trees and birds in many cases are English. The hedges which one sees on every hand are of English furze, here developed into a beautiful golden bush. The paddocks surrounded by this furze present beautiful "pictures of green set in frames of gold."

While the Dominion of New Zealand is a dependent colony with a governor appointed by the English Crown, yet the government is that of the people. There are two deliberative bodies which consist of a Legislative Council and a House of Representatives.

The Legislative Council is at present composed of forty-four men appointed by the Governor, although there is no definite limit to the number which may be appointed except that there must be more than ten. These councilors are appointed for

LYTTELTON, PORT OF CHRISTCHURCH, NEW ZEALAND

a term of seven years and have a speaker elected by themselves for a period of five years. It is stipulated that civil servants and contractors engaged on public works are not eligible to this body.

In the House of Representatives there are eighty members, including native Maoris, who are elected by the people. The legislative districts are apportioned on the basis of population and every adult person is entitled to a vote. It is interesting to learn that fully seventy-five per cent of the women exercise their franchise. Elections are held every three years and members of the House of Representatives receive $1,500 per year during office.

There is an Executive Council, consisting of ten members, of which council the Governor is a member ex-officio. Before any bill can be enacted into law it must receive a majority of votes of those present in the House when the measure was considered; it must also pass the Legislative Council and receive the signature of the Governor, who may veto any measure which does not meet with his approval. However, the veto power is rarely exercised.

Recent legislation has been somewhat socialistic in its tendencies and it is questionable whether the results have been entirely favorable to the general welfare of the people at large. While wages have been increased and the hours of labor reduced, these have both tended to discourage manufacturing and industrial progress, and in consequence, the cost of living, except for food, has been increased. The small number of working hours and the corresponding decreased output, with the high rate of wages paid, renders the cost of production of manufactured goods relatively high in New Zealand and prevents competition in the markets of the world. On the other hand, the climatic conditions are most favorable to the growth of food products; this is also true of the principal staple industries of the country, which consist largely of wool, tanned hides, native flax and the dairy industries. There is a large and increasing business maintained in exporting frozen meat, which finds a ready market in England. The establishment of the packing houses, or freezing plants, as they call them in New Zealand, is of comparatively recent date, and provides a market for mutton and lamb which formerly had little or no value in the colonies. Even now, good mutton is retailed in the shops at four to six cents a pound.

There is a comparatively high tariff imposed on all goods which can be manufactured in New Zealand. Nearly all machinery is imported and is relatively expensive as compared

with the cost in the country of manufacture. New Zealand maintains a preferential tariff in favor of articles made in Great Britain or the British colonies so that the American manufacturer is at a considerable disadvantage; yet the superiority of American-made machinery and the reduced cost of

WANGANUI RIVER, NEW ZEALAND

manufacture, due to the higher efficiency of the American workmen, allows American products to be sold alongside of English imports, and in many cases the Americans have the cream of the business.

The hours of employment have been limited by direct legislation to eight hours a day in nearly all cases, not only in the various industries, but the law applies to stores and

offices as well. All shops and stores must close at six o'clock during five nights in the week, and all employees are granted one-half day per week; this may occur on Saturday or any other week day, and is optional with the local authorities.

An Industrial Arbitration Act, which came into effect some ten years ago, provides that any disputes arising between the employer and employe may be referred to a Conciliation Board for adjustment, and in case this board does not conciliate, either party may refer the matter in dispute to an Arbitration Court, which consists of three members appointed by the governor; the president or judge of the court has the same standing as a member of the supreme court; the other two are appointed upon the recommendations of the unions of employers and workers, respectively.

The present labor situation as stated to me by a prominent New Zealander, intimately acquainted with the conditions, is substantially as follows:

The Arbitration Act was designed to construct, or to aid in maintaining an industrial system which should be free from dissensions, to promote industrial peace and well-being, first, for the benefit of the parties directly concerned, and second, for the protection of the public. The proposition was that the Conciliation Board should first "recommend" parties to work together willingly and peaceably under certain conditions. If necessary, this was to be backed up by an injunction from the Arbitration Court to similar effect. So long as both parties agree this is effective. But, as in the recent strikes, as soon as such agreement fails, the court and the whole system become powerless, and resort must be made to private contract.

The court has power to make awards and to impose fines for breaches of same, with the alternatives of paying or going to jail, but it cannot issue a mandate which shall have the certain effect of preserving or restoring industrial peace where rooted dissatisfaction exists on either side. It can punish a man for striking, but it cannot persuade him to work on terms which are distasteful to him. Or, on the other hand, it may punish an employer for locking out his men, but it cannot make him re-open and run his factory at a loss.

I do not mean to say, however, that the whole scheme of labor legislation is a failure. It is not to be utterly condemned because in extreme exigency it has disappointed expectations; in some respects it is admirable. It gives, in a measure, assurance of settled conditions, and though this is finally dependent upon the consent and loyalty of both parties, it is no small gain. And in so far as it has been effective in

preserving peace in the industrial community, as well as securing justice to the disputants, the Arbitration system may be said to have justified its existence. It cannot, however, be regarded as a final solution of the problem it was intended to deal with.

In New Zealand and Australia the government owns nearly all of the railways, as well as the telegraph system. In New Zealand the expense of construction of the railways has

POSTOFFICE, CABLE, TELEGRAPH AND TELEPHONE OFFICE, PARCELS POST AND GOVERNMENT BANK, AT SYDNEY, AUSTRALIA

been very great,—about $45,000 per mile,—but even with this cost, traveling is not expensive. The rates vary from three cents per mile for first-class passengers covering short distances to two cents per mile on longer runs. The rates for second-class are considerably less. Freight rates are relatively high, but the aim of the government is to keep the rates down as low as possible and yet make three per cent on the money invested.

The railroads are not being developed as rapidly as some of the more progressive people would wish, and government ownership is criticised somewhat for retarding the development of the country.

The telegraph and postal service is excellent, both of which are the cheapest in the world. You can send a message consisting of twelve words from one end of the country to the other, over a thousand miles, for twelve cents, and longer messages may be sent for one cent per word. The result is that the telegraph is utilized to a very great extent as a substitute for the ordinary business letter.

Excellent schools are provided everywhere, but the cost of maintaining them is very high, averaging about $5.00 per capita of population. Public libraries are operated in connection with the educational system and the government pays a part of the cost of their maintenance. Industrial education is being promoted by the establishment of technical schools in all the large centers. In these schools instruction is given to boys in woodworking, patternmaking, molding, machine and forge work, boiler making and wool sorting; the girls are taught dressmaking and cooking.

The New Zealand University is a peculiar institution in that it is merely an examining body, which employs men of eminence in the various branches of science and literature in England to examine candidates for degrees in Arts, Law, Science and Medicine.

There are four teaching colleges in the four large cities, Dunedin, Christchurch, Wellington and Auckland. The Engineering College at Christchurch is equipped with fine laboratories, but there are no shops. Instead, the students put in their summers for four years at the railway shops in the city—a plan which has some merit, but on the whole, it seems less satisfactory than the practice of American colleges which have workshops as a part of their equipment. New Zealand has vast opportunities for the engineer in the development of her natural resources, but at the present time little is being accomplished along these lines.

The land laws have been materially modified during the past few years and present some features of striking interest. No one is allowed to acquire more than a certain amount of government land, which varies from "one section of good farming land to an unspecified area of poor grazing land, which will support 20,000 sheep or 4,000 cattle."

The government also lends money to settlers at a low rate of interest in order that the farmers may the more quickly improve their holdings. $20,000,000 have been loaned to the settlers in this way. In no case does the loan exceed $10,000, nor can it exceed sixty per cent of the value of the land itself.

Another act permits the government to acquire large tracts of land compulsorily for settlement. These tracts or estates are then divided into smaller holdings and rented for 5 per cent of the cost price.

All land is subject to a direct tax equal to 40 cents per $100 of the land valuation. Improvements are not considered as a part of the land values, and reductions are made for any mortgages which may cover the property. The mortgages, however, are taxed separately. There is also a graduated land tax imposed on all properties which have an unimproved value of $25,000 or over. The lowest rate of this tax is 5 cents per $100 of value, which is increased to as much as $1.20 per $100 when the value of the estate is $1,000,000 or more.

New Zealand has also an income tax which amounts to about $2.40 per $100 on all incomes greater than $1,500, and less than $5,000 per year; on incomes greater than $5,000 the rate is doubled.

Many experiments in legislation are being carried out, some of which have already proven to be impracticable; but the people are finding out what they want, and the general prosperity of the country, due largely to agricultural causes rather than to industrial, has so far enabled them to carry out this legislation without disaster. However, a feeling of unrest is quite apparent and it is difficult to speculate as to results, if a period of depression were to occur. It is certain that labor legislation has checked industrial development to a considerable extent both in New Zealand and in Australia, where similar conditions obtain in large measure. Hardly any new manufacturing industry has been developed of late years, owing to a hesitancy on the part of capital to engage in any enterprise in which labor is an important element.

Both capital and labor are dissatisfied with government regulation, and New Zealand at the present time is far from being the Utopia which we have been led to believe exists in the southern Pacific.

CONCRETE PILES.

By Stewart G. Collins, '04.

In entering upon a discussion of concrete piles, it is perhaps necessary to begin by answering the question—"Why should concrete piles be used?" Wood piles have been used for centuries with success, and are certainly cheaper than concrete, so why should they be displaced?

The argument for the concrete pile is: it is good for all time; it does not rot or decay; the teredo cannot injure it and the water level is a matter of indifference to it. Wood piles must always be cut off below the permanent water level in order that alternate wetness and dryness may not rot them, and this water level is sometimes changed. In lower New York several buildings are on piles, the tops of which are exposed owing to deep cellars and tunnels in the neighborhood which have lowered the water level.

Another advantage is the greater loads that can be put on concrete piles. They can be built with reinforcing similar to that in a concrete building column, and will sustain three or four times the load that is safe on a wood pile. And finally, the footings or walls which rest on the piles may be started at the surface of the ground, or just below the frost line, saving the excavation and concrete required if wood piles must be cut off below water. This is often important as it means considerable time saved and generally considerable expense, for when the foundation builder strikes water his trouble begins.

Of concrete piles there are two classes, the built-in-place and those molded and then driven. The latter may be dismissed with a few words as they can be driven safely only by jetting, and this is feasible only in sand. They cannot be hammered to firm bottom without being broken to pieces.

Of the other class there are two systems which have been used quite extensively in this country—the Raymond and the Simplex methods.

The Raymond is a tapered point pile 6-inch diameter at bottom and 20-inch or less at top, and has a sheet iron casing around it for the full length. It is driven with an ordinary pile driver either by jet or drop-hammer, or steam. A

steel mandrel is used which is the exact size of the pile and this is covered with sheet iron built like stove pipe. The mandrel is driven to the proper depth and then collapsed when it can be removed, leaving a hole in the ground surrounded by the casing. This hole is then filled with concrete, reinforcing rods being put in if required.

Its disadvantages are in its tapered form and in the steel casing. It is so small at the point that it has little bearing area where area is required. The value of a pile lies in its bearing at the point where the soil is good—this is evidenced by the recommendation by prominent engineers that wood piles be driven butt down. If friction is to be relied upon the frictional surface should be large at the lower end and this

Fig. 1 ALLIGATOR JAWS

surface should be something rougher than stove pipe. The Raymond pile cannot be driven where the soil is soft enough to collapse when the core is withdrawn, or where the soil is solid enough to strip the casing during driving.

Its chief advantages are the speed with which the piles can be driven, and the certainty with which they are made, if they can be made at all.

The Simplex method which is also a patented one, is happily named. It is driven with an ordinary driver, built heavier than for wood piles, using a jet or drop hammer.

The indispensable part of the outfit is a pile form which is a steel pipe of ½-inch or ¾-inch metal 16-inch diameter outside, and fitted with what are called alligator jaws. (See Figure 1.) A steel head block holds this pipe in the leads of the driver and a 3,000-pound hammer, falling on a wood cushion, drives the pipe into the ground. This form can be driven in soil impenetrable to a wood pile and to a bearing that would smash a wood pile to pieces. When the form is driven to the required depth or penetration concrete

is dumped into the pipe, being hoisted in buckets from a mixing board (Fig. 3) conveniently situated, and reinforcing put in at the same time. The pulling purchase is then started and the pipe slowly pulled out of the ground until it is clear. The static head of the concrete in the pipe opens the jaws the minute the pipe starts up, and the concrete flows out of the lower end, filling the hole. This makes a cylindrical column, the exact size of the pipe, and the concrete is in contact with the surrounding earth and is cemented to it. In filling the pipe with concrete, the level of the concrete is several feet

Fig. 2 — CAST IRON POINT FOR USE IN HEAVY SOIL

Fig. 3 — FILLING A CONCRETE PILE.

above the ground, as there will be more volume in the hole than in the pipe. This causes the concrete which is put in in a sloppy condition to fill every hole and void in the soil, and does away with the necessity of ramming. Piles have been dug up which had large stones firmly cemented to them, but outside of the pile, as the steel pipe forces every obstacle to one side; it has often been driven through old brick foundations, timber footings, old docks and cribs and in every soil except one containing large boulders.

In some soils the alligator jaws cannot be used as the pressure closes them and prevents the concrete from running freely. In this event, a smooth pipe is used and a cast iron point which is left in the ground. (Fig. 2.) In very soft soils where there is danger of the concrete being mixed with mud before it sets, a steel shell is used. Concrete is first filled in the pipe to the height of the firm soil which takes the

bearing. This shell is then dropped in and filled with concrete and the form pulled out. Piles of this type with 8 to 10 feet in sand and 20 feet in soft muck—this 20 feet being reinforced and acting as a column—are safely loaded with 45 tons. The ordinary Simplex piles have been tested to 60 and 70 tons with no settlement, and structures are being built in which single piles are loaded up to 45 tons. They have been used to support bridge piers, engine beds and tanks as well as buildings, and are used singly as well as in groups. One structure recently finished is a reinforced concrete platform, the columns of which are these piles built up in the air, with the column reinforcing extending 5 feet into the piles. The buildings are also on piles, each steel column resting on a cap over one or two piles. Reinforced concrete girders level with the ground between the piles carry the building walls.

Pulling the pipe after it is filled with concrete is sometimes the most troublesome part of the work. The drivers are built extra heavy to do this work and a purchase of eleven parts of ⅝-inch steel cable is used. It is operated on the lower drum of an ordinary hoisting engine, the hammer fall being on the upper drum. It is sometimes necessary to wind the purchase cable on a third drum which gears with the lower one and multiplies the power ten times.

The good features of the Simplex pile are its constant diameter and its roughness. If it is a bearing pile it is large enough at the bottom to support the load on top, and if it is supported by friction its size and surface are in the right place.

In conclusion, I wish to say that the concrete pile people do not intend to run the wood pile entirely out of existence. They have found to their sorrow generally, that concrete piles can be used successfully only in certain places, and that each system has its own peculiar advantages.

The photographs were taken on work done by The Foundation Company of New York.

VALUATION OF RAILROAD PROPERTY IN MINNESOTA.

By A. S. Cutler, '05.
Instructor in Railway Engineering.

One of the greatest problems before the country at the present time, as far as business interests are concerned, is the regulation of large combinations of capital. During the last two years the attention of the public has been especially directed towards these great corporations, and nearly all of them have been the object of attack, both by the people and the legislatures. In many instances the measures introduced and adopted, looking toward their proper regulation, have been unreasonable and unjust.

Probably the greatest cause of this unwise legislation has been the lack of accurate and reliable information in our legislative bodies concerning the issues under discussion. In the case of the legislation affecting railroads and their operation, this has been especially evident.

Practically every railroad bill recently introduced has had for its primary object the reduction of rates, both passenger and freight, an increase in the rate of taxation, or an increase in the assessed value of the properties. Whether these rates are unjust and confiscatory or not, the enactment of this legislation has resulted in decreased dividends to the stockholder and in depreciation of the stock values. Any law concerning the control of such property, the result of the enforcement of which can be measured in dollars and cents, should have for the basis of its enactment a money value representing the actual investment in the property. In readjusting the railroad situation it is imperative that a foundation be laid upon which to construct fair and equitable rates. The supreme court of the state of Minnesota has held that the question of what constitutes reasonable rates can only be determined by ascertaining what would be a reasonable income on the cost of reproducing the railroads at the present time, under present conditions. With this end in view the Minnesota state legislature adopted a joint resolution calling for a readjustment of the

rates and authorizing the state railroad and warehouse commission to make a valuation of all the railroad properties in the state.

The magnitude and very great importance of this work demanded that it be placed under the direction of a man of great engineering ability and of extensive railroad experience in order that the state might be qualified to testify in court as an expert on the question. Such a man was found in Mr. Dwight C. Morgan, who was appointed expert engineer for the railroad and warehouse commission, in charge of the valuation of railroad properties.

The enormous amount of information to be secured and a knowledge of the conditions existing on the various railroads of the state required the work to be thoroughly systematized. Accordingly a series of about fifty forms, following the general outline of the Interstate Commerce Commission, were prepared, covering in detail every item in the construction and equipment of a railroad; such as the present value of lands for right of way, yards and terminals; the cost of grading, tracks, bridges, buildings, shops, machinery and tools, engine houses and turntables, locomotives, freight and passenger equipment, etc. On pages 72, 73 and 74 are shown headings of forms number 1, 5, 16, 23, 25, 50 and 51, which are typical of the entire set, and which show the great care taken to get accurate and reliable reports.

The methods used for obtaining and checking the desired information were more accurate and impartial than those used in any former investigations along this line.

As soon as the blank forms were prepared a supply was sent to the general manager of every railroad operating in the state, who was requested to fill them out carefully and fully and to return them to the commission by a certain date.

On account of incomplete construction records, and in many cases the lack of any records whatever, it was necessary for the railroads to go into the field to secure the information called for on the report. Parties were sent out, and in many cases complete surveys were made, track and ground profiles were run, widths of cuts and embankments checked, bridges and culverts inspected and measured, the amount of each weight of rail and the number and kind of switches determined, and the dimensions and conditions of all company buildings noted.

When no construction records were available the amount of excavation and embankment was obtained by scaling the original or a new profile, and the acreage of right of way,

given under various widths, was computed from surveys and maps. To secure this information a personal inspection of all the property owned by the railroad by a competent engineer was necessary.

As fast as the field work was completed the notes were sent into the office, where they were reduced and the results tabulated and placed on the forms in accordance with the instructions furnished by the commission.

An inspection of the forms will show that each railroad was divided into sections, each section being usually taken as a branch, division or some length of line convenient for recording and checking the information. After all the quantities for one section had been reduced the totals were carried forward and shown on the section summary sheet, form 50. Before form 50 could be completed and the cost of reproduction determined it was necessary to give to every individual item a unit price.

In order to fix upon the unit costs, all the conditions effecting the construction of a railroad at the present time were considered, such as the current prices for material, the conditions and cost of labor, the methods employed for doing the work, and the specifications governing the construction. After these unit prices were fixed, the section summary sheets were reduced and the totals carried forward to the final summary sheet, form 51. An examination of this sheet shows the total cost for construction and equipment, and in addition, all the items properly chargeable to construction account.

After the report was completed by the railroad it was returned, accompanied by complete maps and profiles of the entire line, to the commission, and there carefully checked.

A field inspection similar to that made by the railroad was then made by the commission. The engineer and one or more members of the commission, accompanied by several assistants, and in most cases by the chief or division engineer of the railroad being inspected, were furnished a special train and the entire mileage of the road was carefully gone over. The engineer for the commission carried with him the exact report furnished by the railroad and stops were made at least every mile to check widths of embankment, cuts, and right of way, and also at all bridges and culverts to check their length and condition. In short, a complete and thorough examination was made of all the railroad property.

In nearly every case the field and office inspection made by the commission checked very closely the reports submit-

Form 1

Name of Operating Company.....

Section Number ..... From..... To.....

Length of Main Line Roadway..... Miles

MINNESOTA RAILROAD & WAREHOUSE COMMISSION
RAILROAD APPRAISAL OF 1906

Lands For Right of Way, Yards & Terminals

Separate by Counties, and for Incorporated Cities, Villages and Towns.
Show Joint Right of Way Separately and Indicate Division of Ownership.

..... Field Inspector.

..... Office Compiler.

	LOCATION	Name of County	Name of Incorporated City, Village, or Town	WIDTH OF RIGHT OF WAY					Total Acres Right of Way	Average Market Value	Average Right of Way Value	LANDS FOR YARDS AND TERMINALS		Average Market Value	Average Value for Railway Purposes	REMARKS
				Feet	Feet	Feet	Feet	Feet				Location	Total Acres			
				Miles	Miles	Miles	Miles	Miles		Per Acre	Per Acre			Per Acre	Per Acre	

Form 5

Name of Operating Company.....

Section Number ..... From..... To.....

Length of Main Line Roadway ..... Miles

Length of Passing, Side and Industry ..... Miles

MINNESOTA RAILROAD & WAREHOUSE COMMISSION
RAILROAD APPRAISAL OF 1906

Roadway Report

In Reporting Information, Show Main Tracks Separate From Passing, Side, and Industry Tracks:
Show Joint Tracks Separately, and Indicate Division of Ownership

..... Field Inspector.

..... Office Compiler.

	LOCATION	SPLIT SWITCHES			STUB SWITCHES			SWITCH STANDS			SWITCH LAMPS			RIGID FROGS					SPRING RAIL FROGS					GUARD RAILS					RAILROAD CROSSINGS				
		Complete Including Connecting Lead			Complete Including Connecting Lead									Lengths of Point					Lengths of Point					Length in Feet									
		Wt. Rail	Number	Condition Per Cent	Wt. Rail	Number	Condition Per Cent	Kind	Number	Condition Per Cent	Kind	Number	Condition Per Cent	Wt. Rail				Condition Per Cent	Wt. Rail				Condition Per Cent	Wt. Rail			Condition Per Cent		Wt. Rail	Name of Railway Crossed	Per Cent Cost Paid By This Co.	Per Cent Maint. Paid By This Co.	Condition Per Cent

Form 16

Name of Operating Company.....

Section Number..... From..... To.....

MINNESOTA RAILROAD & WAREHOUSE COMMISSION
RAILROAD APPRAISAL OF 1906

Engine Houses and Turntables

..... Field Inspector.

..... Office Compiler

	LOCATION	ENGINE HOUSES														TURNTABLES							TURNTABLE PITS				
		Material in			No. of Tire Tracks	Depth of Pits	Number of Stalls	Pits			Heating		Smoke Jacks		Age of Building	Condition Per Cent	Type of Table	Length Feet	Depth Ft.	Location Approximate Town	Turning Apparatus	Age of Table	Condition Per Cent	Under Foundation	Crossing		Kind Paving	Condition Per Cent
		Foundations	Walls	Frames				Number	Material	Dimensions	Stoves	Hot Air	Kind	No.											Brick	Paving Blocks			

Form 33

MINNESOTA RAILROAD & WAREHOUSE COMMISSION
RAILROAD APPRAISAL OF 1906

Signal Apparatus

Name of Operating Company _____
Section Number _____ *From* _____ *To* _____

_____ *Field Inspector*
_____ *Office Compiler*

Location	Train Order and Manual Block Signals Operated in Connection with the Telegraph					Automatic Block Signals							Distant Semaphore Signals			Electric Selective Train Control Installations				
	Type of Signal	Manufactured By	Number Installed	Condition Per Cent	Miles of Single Line Protected	Type of Signal	Manufactured By	Number Installed	Number Switch Indicators	Direct Track or Wire	Miles of Single Line Protected	Condition Per Cent	Type of Signal	Number Installed	Condition Per Cent	Location	Manufactured By	Number Installed	Direct Track or Wire	Condition Per Cent

Form 35

MINNESOTA RAILROAD & WAREHOUSE COMMISSION
RAILROAD APPRAISAL OF 1906

Locomotives

Name of Operating Company _____
Locomotive in Service in Minnesota _____ *Total Number*

_____ *Field Inspector*
_____ *Office Compiler*

Name of Builder	ENGINES														TENDER		Total Weight Engine & Tender Loaded	Cost of Reproduction	Condition Per Cent
	Engine Number	Class	Simple or Compound	Service	Dimensions of Cylinders	Diameter of Boiler	Working Pressure	Driving Wheels No.	Driving Wheels Diameter	Weight on Driving Wheels	Weight on Trailing Wheels	Weight on Truck	Heating Capacity	Brake Equipment	When Built	When Given General Repairs	Water Capacity	Coal Capacity			

Form 50

MINNESOTA RAILROAD & WAREHOUSE COMMISSION
RAILROAD APPRAISAL OF 1906

Section Appraisal Sheet

Name of Operating Company _____
Section Number _____ *From* _____ *To* _____
Length of Main Line Roadway _____ *Miles*
Length of Passing, Side, and Industry Tracks _____ *Miles*

Sheet Number _____
Date of Compilation _____ *190*__
Compiled By _____

GENERAL DESCRIPTION AND ITEMIZATION Use as Many Sheets as Necessary to Record Items Shown on Detail Sheets; Grouping Under the Sub-Headings and in the Order Shown on Final Summary Sheet, Form 51.	Cost of Reproduction New	Condition Per Cent	Present Value

ted by the railroads. The quantities for grading, which allowed of the greatest variation, checking within from 2 per cent to 10 per cent. Wherever errors or omissions were dis-

Form 51.

MINNESOTA RAILROAD & WAREHOUSE COMMISSION

RAILROAD APPRAISAL OF 1906.

Final Summary Sheet.

*Name of Operating Company*_____

*Section Number*_____

*From*_____ *To*_____

*Miles Single Main Track*_____ *Miles of Branch Lines*_____

*Miles 2nd Main Track*_____ *Miles of Passing, Side and Industry Tracks*_____

*Miles 3d Main Track*_____

*Miles 4th Main Track*_____

Cost of Reproduction and Present Value of Physical Properties

SUBJECT	COST OF REPRODUCTION NEW	PRESENT VALUE
1 Land for Right of Way, Yards and Terminals		
2 Grading, Clearing and Grubbing		
3 Protection Work, Rip Rap, Retaining Walls		
4 Tunnels		
5 Cross Ties and Switch Ties		
6 Ballast		
7 Rails		
8 Track Fastenings		
9 Switches, Frogs and Railroad Crossings		
10 Track Laying and Surfacing		
11 Bridges, Trestles and Culverts		
12 Track and Bridge Tools		
13 Fences, Cattle Guards and Signs		
14 Stock Yards and Appurtenances		
15 Water Stations		
16 Coal Stations		
17 Station Buildings and Fixtures		
18 Miscellaneous Buildings		
19 Steam and Electric Power Plants, Gas Plants		
20 General Repair Shops		
21 Shop Machinery and Tools		
22 Engine Houses, Turntables and Cinder Pits		
23 Track Scales		
24 Docks and Wharves (Include Coal and Ore Docks)		
25 Interlocking Plants		
26 Signal Apparatus		
27 Telegraph Lines and Appurtenances		
28 Telephone Lines and Appurtenances		
29		
TOTAL OF ITEMS 1 TO 29 INCLUSIVE		
30 Engineering Superintendence Legal Expenses,____ %		
TOTAL OF ITEMS 1 TO 30 INCLUSIVE		
31 Locomotives		
32 Passenger Equipment		
33 Freight Car Equipment		
34 Miscellaneous Equipment		
35 Marine Equipment		
TOTAL OF ITEMS 1 TO 35 INCLUSIVE		
36 Freight on Construction Material and Equipment, __ %		
37 Interest During Construction __ % Organization ___ % Contingencies __ % Total ___ % Items 1 to 37 Inclusive		
38 Stores and Supplies in Minnesota		
GRAND TOTAL		

covered they were promptly called to the attention of the railroad and corrections were made.

Although the information furnished by the railroads was checked so closely by the commission, it does not follow that the final report of the commission to the legislature, giving actual values, both for reproduction and present condition, will agree with the values fixed by the railroads. On account of the widely differing opinions of engineers and operating

officials as to whether certain items of expense should be charged to construction, maintenance of way or operating accounts, the values given for unit costs, in many cases, show great variation. This may be better understood by taking up some of the more important questions.

In the case of right of way as shown on form 1, the values both as farm property and as railroad property are called for. The value as farm land is easily obtained by an inspection of real estate transfers or by consulting reliable real estate men, but the value of this same property to the railroad company is not so easily arrived at, as many items, such as damages paid to adjacent property owners, costs of condemnation proceedings, attorneys' and agents' fees, cost of filing papers, etc., enter into this value. By taking all these charges into account it will be found that the actual cost to the railroad company in acquiring this property has greatly exceeded the original value of the land.

In some cases the right of way was donated to the railroad, but by taking the actual cost of an entire section or division, it will be found that the value to the railroad company is to the market value of the land about as three is to one. This ratio will cover practically all cases of farm land taken for railroad purposes outside of cities and villages. In coming into a city and acquiring land for yards and terminals the relative value decreases until it is only about 1.25 to 1. This is due to the fact that the city property has a greater market value and that the damages and expenses incurred are less in proportion to this market value.

The unit costs for earthwork probably allow of greater variation than any item in the report. The topography of the country, the condition of the soil, the particular specifications under which the work is carried on, and the limits of free haul and overhaul, all have their effect upon the unit cost. Form 2, which shows the earthwork quantities does not call for the amount of overhaul, and as this forms a large percentage of the cost of grading, it is necessary to give a unit cost for excavation, which will cover this cost of overhaul. By examining construction records, or by making an approximate estimate for earthwork, it will be found that in the construction of the average Minnesota railroad there are about two units of overhaul for every unit of paid quantity. Having given, then, the unit costs both for excavation and overhaul, the value of the grading itself can be readily determined. To this should be added an amount covering the expense to the railroad company of transporting, free over

the company's lines, the contractors' men, teams and tools, equal to about 2 cents per cubic yard of pay quantity.

The total unit cost thus determined cannot be applied to all localities, for the conditions existing on every section, or even on every mile, may be such that a new unit value must be computed.

Another charge which properly belongs in the construction cost, but which is not called for in this report, is a charge covering the increased value of the roadbed, both in cut and fill. After a railroad has been graded and put into operation a large sum of money is necessarily spent in finishing and putting into proper condition work which should have been done by the construction contractor. The slopes have been left uneven and rough, the ditches are not out to their full section, highway and private crossings are left impassable, and the drainage has not been properly provided for. During the first season's storms the slopes are washed down, ditches filled up and drains choked. All this loose material has to be cleared out and disposed of; during the same time the embankments have been constantly settling, and in order to keep them up to grade the track has to be picked up and cinders or ballast placed under it. This in time is packed down and the operation is repeated. Every year the embankments become more solid, the cuts take their natural slope and the entire line approaches the condition of a "permanent way."

This extra work costs a large amount of money, and it may be held by some that it is purely maintenance of way and has nothing to do with the original construction cost. It might be possible, however, by the expenditure of a great enough sum of money to approach this condition during the original construction period, so that the future maintenance charges would be reduced to a minimum. The actual value of this work cannot be easily determined, but as an arbitrary amount, 15 per cent of the actual cost of the grading is not too great a charge.

There are many other items which allow of great variation in their unit costs, owing to the peculiar conditions affecting each, such as the cost of pile and timber trestles, culverts, track laying, surfacing, ballasting, etc.

Whatever the final report may be, it is sure to prove of inestimable value not only to the state as reliable data upon which to base intelligent action, but also to the railroads as a permanent record of construction costs and of present valuation.

The work of the commission is proceeding with all possible haste, and the report is expected to be ready for presentation to the next session of legislature.

Minnesota is the pioneer in this work of accurate railroad valuation, but the methods being pursued and results being obtained show that the problems are being carefully and scientifically solved.

EAGLE HARBOR, WASHINGTON, WITH THE PLANT OF THE PACIFIC CREOSOTING COMPANY IN THE BACKGROUND.

TIMBER PRESERVATION.

A Description of the Creosoting Process and of the Plant of the Pacific Creosoting Company.

By Ralph H. Rawson, M. E., '07.

The demand for preserved timber on the Pacific coast is one that is receiving a great deal of consideration at the present time. The scarcity of good lumber and the increasing prices now make timber impregnated with some sort of antiseptic almost necessary. Since the creosoting process of preservation has proved to be the most efficient for general purposes, by virtue of its ability to resist the action of salt water better than timber impregnated with metallic salts, we find that this character of treatment is used to a great extent.

There are many good reasons why wood should be treated with preservatives, for it is a well known fact that untreated wood, as piling, when placed in salt water, is soon "honeycombed" by the Teredo Navalis. Railway ties when given the proper treatment of creosote have been found to be much more lasting than the untreated ones, and, while the initial investment may be more, yet it has been found to be a profitable one. Also paving blocks, when they have received the creosote treatment, will last a life-time. Bridge timbers, and, in fact, any timber that is to be exposed to the elements, oftentimes outlive the usefulness of the structure or piece of work that they have been put into when they have been treated with creosote as a preservative.

The Red Douglass fir (Pseudotsuga Taxifolia), since it is found in great abundance in the Western states, and since it possesses exceptional strength and stiffness, is used almost to the exclusion of all other woods. It is of a hard structure and absorbs the oil with a great deal more difficulty than the softer Southern woods.

The treatment of the wood we can see will depend upon its nature and the uses it is to be put to. As for example: piling that is to be placed in salt water where it will be subjected to the ravages of the teredo will require more oil than telephone poles; or piling placed in warm water will require a heavier treatment than those placed in cooler water. The

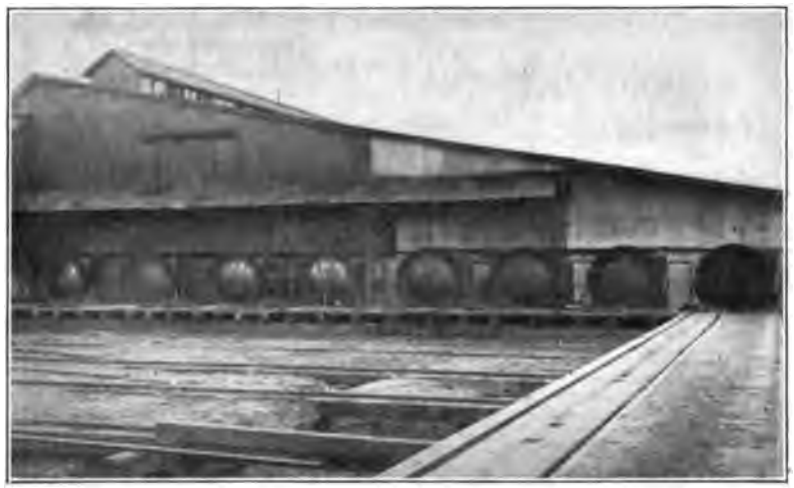
amount of creosote to be injected and the methods of injecting are problems that have been solved by experience, so that at the present time the methods are all well worked out.

Of the different methods now in use only two will be mentioned in this article—the one used by the Pacific Creosoting Co. and the Steaming-Vacuum process, used to a great extent in the Eastern and Southern states.

SECTIONS OF UNPROTECTED PILES AFTER EXPOSURE FOR ONE YEAR IN SEA WATER.

In the first mentioned case the green timber is loaded onto tram cars and run into the retorts, which are then sealed up. The retort is now filled with enough creosote to completely cover the wood and the temperature is gradually raised until it reaches about 215 degrees or 225 degrees Fahrenheit (this temperature depending on the condition of the wood when it goes into the retort). This temperature is maintained until the water in the timber is thoroughly driven off, the scheme being to pass the vapors through a condenser, and when the rate of condensation has reached a certain value it is known that the wood is practically dry. This method of seasoning has been found to be a very satisfactory one, it requiring about 48 hours for piling, 5 to 6 hours for paving blocks, 25 hours for sawed timbers, and at the same time it does not require a high degree of temperature which would injure the fibre of the wood, as the steaming-vacuum process often does. Next the retort is completely filled with creosote, all openings are

closed, and a predetermined amount of oil is pumped in. This amount depends upon the treatment the wood is to receive. This last step requires about a half hour for a 12-pound treatment of piling and about one and a half hours for 12-pound treatment of sawed timber. This variation in time is caused by the differing readiness with which the oil penetrates the sap and heart wood. The retort is now pumped dry; or in some cases is blown out by air pressure. The load is removed and the retort is ready for another charge.



EXTERIOR OF RETORTS, SHOWING ACCESS BY TRANSFER TABLE.

The second process differs greatly from the first in that the wood is seasoned by turning live steam into the retort after the load is in. This steaming process lasts from 10 to 18 hours, depending on the condition of the wood. At the end of the steaming the condensation is pumped out from the bottom of the retort and a vacuum of 22 or 24 inches is now maintained for a period of from five to eight hours. During this time steam is passed through the heating coils. After the vacuum has been removed hot oil is admitted into the retort and the oil pump forces still more into the wood, under a pressure of 150 pounds per square inch. The theory of this process is that the live steam opens the pores of the wood, and, by having the steam passing through the heating coils during the vacuum, the sap is vaporized and carried off by the vacuum pump. The vacuum, being in the wood when the oil is admitted, has a tendency to draw the oil into the pores; that, with the oil pressure, impregnates the wood with the desired amount of oil. The chief difficulty, which has already been

A VIEW LOOKING DOWN THE LOADING DOCK TOWARD THE RETORTS

pointed out, is that such a high degree of heat is often carried in the retorts that the fibre is in a great many cases impaired, whereas, with the first process it is known to a very fine degree of certainty when the moisture is out of the wood; and, at the same time it can be obtained with a low degree of heat, i. e., 215 to 225 degrees F.

The building of a plant to treat wood for preservation is a question which should receive a great deal of consideration, and necessarily requires a great outlay of money. Neither of these points seems to have been spared in the development of the Pacific Creosoting Company's plant at Eagle Harbor, Wash. The plant proper, docks and yards of this company occupy about 10 acres of reclaimed land—docks alone having 45,000 square feet. Provision has been made for the loading and unloading of sailing vessels from the company's docks. The green timber, as it comes from the boom, is loaded onto the tram cars by two large double boom derricks. A transfer table is used to shift the cars to tracks leading to the proper retort. The docks have also a locomotive crane which handles the loading and unloading of timber and paving blocks. A block sawing rig, capable of sawing 30,000 feet B. M. per day, is also installed here.

The equipment of the plant consists of eight large retorts, six of them being 125 feet long and the remaining two being 115 feet long. They are constructed of 5/8-inch steel, 6 feet in diameter, and are capable of standing a working pressure of 250 pounds per square inch. Each of these retorts is fitted with heating coils for obtaining the desired temperature in the different processes. Six 150-horsepower boilers are installed to furnish steam for heating and for running the necessary pressure, vacuum and service pumps, and the auxiliary machinery throughout the plant. The lighting is accomplished with a 30 kilowatt direct connected unit. The creosote oil is stored in three large tanks having a total capacity of about 600,000 gallons.

In addition to the large retorts the company has equipped an experimental plant which has a small retort 6 feet in diameter and 10 feet long. This experimental retort is used to try out the different processes and methods of treatment under a wide range of conditions in order to determine the best practice for the large retorts. A small service pump is used to pump the creosote from the retort to the measuring tank, and a 6x4x6 Snow pump is used for pressure. An interesting feature is to be noticed in the way the oil is blown out of the retort into a high tank—a Westinghouse air pump accom-

plishes this very nicely. This same pump is used for a vacuum pump when the occasion demands.

An interesting feature of this industry is in the length of operation. The plant is run 365 days in the year, never closing down a moment unless in the case of some serious accident—a thing which seldom occurs, as the equipment is such that repairs can be made without disabling the entire plant.

Where such large quantities of creosote oil are used it is necessary to have some means of testing it from time to time. To meet this demand the company has set up a very complete

A TRUCK LOAD OF CREOSOTED PILES

laboratory equipped with all the apparatus that is needed to carry on elaborate tests.

With the present equipment and running conditions the plant has a capacity for treating 44,000,000 feet B. M. of lumber per year, or 2,000,000 lineal feet of piling per year, making it the largest creosoting plant in the world.

There seems to be a variety of opinions as to the effect that creosoting has on timber. Beyond all doubt the life of the wood is prolonged, but it cannot be said that the strength is materially increased by this process. By virtue of the fact that the wood has been seasoned after treatment it would necessarily be somewhat more stiff and durable than the unseasoned wood. If an untreated railway cross-tie could be placed where it would be subjected to the mechanical wear and not to rot it would last from 12 to 15 years. A creosoted

tie, where it is subjected to both rot and the mechanical wear, would last the same length of time, but usually the creosoted tie will be found to be sound in places where the wear does not come. We have the life of the untreated tie rated at about one-third of the life of the creosoted tie, both being subjected to the same conditions.

The United States Department of Agriculture, through the Bureau of Forestry at Seattle, Wash., are now carrying on a series of experiments which are intended to show the strength of untreated green and seasoned timber as compared with that of treated timber. The results of these tests will be published, no doubt, by the government, and it is regretted that some of this data is not obtainable for this article.

Naturally the cost of treated wood is in excess of the cost of untreated wood, but, as it has been mentioned before, the life of the wood is prolonged to such an extent by treatment that it is a very economical material to use. No definite figures can be given that will show the cost of treated timber as compared with the untreated wood, because the fluctuations in the cost of creosote oil, the labor and local conditions, make it a varying quantity.

The whole question of cost seems to have been very well summed up in a paper read by Mr. W. W. Curtis before the New York Railway Club some time ago, in which he quotes Mr. R. Montfort, chief engineer of the Louisville & Nashville, to the effect that creosoted piles driven in 1876 as piers for iron bridges in the neighborhood of New Orleans are today in perfect condition, while the metal bridges which they support are being renewed. Such statements justify the attitude of the bridge engineer of one of our great railway systems, who defines a creosoted timber trestle as a "permanent structure." When to this is added the testimony of a chief engineer of another great railroad to the non-inflammability of creosoted timber after one year of service, the mystery deepens as to the slowness with which railways accept the inevitable necessity for some effective method of preserving timber—a mystery which is only partially explained by Mr. Walter Berg's opinion, embodied in his discussion of Mr. Curtis' paper, that "the first cost of preserving timber falls upon the yearly estimates, and the ultimate saving accrues as a benefit to some subsequent management."

THE PRESENT STATUS OF THE GAS ENGINE.

By H. D. Frary, '08.

The last few years have witnessed a somewhat phenomenal, though healthy, development in the field of gas power. This development has done much toward perfecting the gas engine mechanically. It has greatly broadened its field of usefulness. It has brought forth the high power gas engine to compete with the high power steam engine and steam turbine. But most important of all, this development is shown in a change of attitude on the part of engineers and the world at large toward the gas engine as a prime mover.

It was only ten or twelve years ago that the majority of engineers and power users looked with distrust upon the gas engine, and refused to use it except in small sizes for special purposes. Today, although some still persist in this policy, the great majority of progressive, experienced men have come to believe that the gas engine has so far passed the experimental stage of its development, that (with equal care in design and equally intelligent operation) it may be placed on an equal footing beside the steam engine.

How has this change of attitude been brought about? Not by proving the superior efficiency of the gas engine over the steam engine; this has been recognized from the first and is indisputable; but by overcoming, to a great extent at least, certain practical obstacles in the way of the gas engine, such as spring up in the path of every new project or invention. These obstacles have been mainly three: (1) *Unreliability—continued troubles and breakdowns;* (2) *Poor speed regulation;* (3) *Inability to stand an overload.* We will proceed to show how and to what extent they have been overcome.

The first obstacle, namely *unreliability,* is by far the most important of the three. No matter if the gas engine be twice as efficient as the steam engine, if it is subject to continual breakdowns, the power user, who wants continuous service, must discard it in favor of its less efficient but more reliable rival. Reliability, then, is essential, and it has been the attainment of this reliability, more than any other thing, that has put the gas engine on a parity with the steam engine. The gas engine of today is as reliable as the steam engine.

Notice, we do not maintain that every gas engine or every make of gas engine is as reliable as the average steam engine. Unfortunately, there are a great many small firms that have gone into the manufacture of gas engines purely to make money for the present, and have built and sold them without regard to existing requirements and conditions. It has been such installations as these that have kept prejudice alive. But we have no more right to judge the gas engine by such monstrosities than to judge the efficiency of the steam engine by the performance of a little donkey hoisting-engine. No company would think of selling that donkey engine to run an electric light plant, yet there are a good many gas engine salesmen who do not hesitate to propose a hit-or-miss gas-engine, designed for a threshing machine, as filling the requirements exactly.

On a par with this is an instance cited by Prof. Fernald in his paper before the Western Society of Engineers. An old man owned and operated a small grist mill which used power perhaps three hours in the day on the average. A salesman for a prominent manufacturing firm persuaded him that a gas producer and engine were just what he wanted. Needless to say, it was not long before the whole outfit was rusting in a dark corner of the mill and an electric motor was being used instead. Such methods not only defeat themselves in the end, but are also sources of prejudice against the gas engine. Nevertheless, power users today are rapidly learning which manufacturers design a reliable gas engine, and hundreds of such engines are now operated with absolute satisfaction.

The second obstacle, namely, *poor speed regulation,* raised a formidable barrier between the gas engine and electric power generation, limiting its field to the running of threshing machines, small shops and the like. The speed of an electric generator should not vary more than about 1 per cent under the most variable load. This is readily attained with the steam engine, in which the piston receives two separate impulses per revolution, and the maximum pressure is not over twice the mean effective. But with the ordinary four-stroke-cycle gas engine, where we have one lone impulse in two revolutions and a maximum pressure during that impulse of from three to six times its M. E. P., such heavy flywheels are required, and in fact all parts must be so large as to preclude its use in sizes over 50 or 75 horsepower.

Various methods may be and have been used to obviate these difficulties. There are the twin and the triplex engines, in which two and three cylinders side by side are connected

to the same shaft, their cranks being set at 180 and 120 degrees apart, respectively. Then there are the tandem, the twin tandem and the double opposed types. By combining cylinders in these ways the variations in the resultant crank effort are greatly reduced, and consequently the weight of flywheel necessary is correspondingly less. These types are satisfactory up to 200 or 300 horsepower, giving a fair regulation, but they take up an immense amount of space and are very expensive to build compared with the equivalent steam engine.

To overcome these disadvantages the double-acting engine has been invented and put on the market. In the double-acting engine the cycle takes place on both sides of the cylinder, as in the steam engine, so that we have one explosion for every two strokes instead of four, thus enabling us to get twice the power out of the same cylinder. The result is that, of the four cycle engines, the double-acting is now used exclusively for powers from 500 horsepower up. The double-acting tandem and twin-tandem are now the standards of nearly all American builders. In the steel industry these two types, operating on blast furnace gas, are now employed for blowing engines, to the exclusion of the steam engine. Some 200,000 horsepower of these engines, in units from 2,000 to 4,000 horsepower, have been installed or ordered during the last two years by iron and steel companies of the United States. Moreover, several large gas engine installations using producer gas have recently begun operation, notably the plant of the Boston Elevated Railway. Large power users all over the country are watching these existing plants very closely, and they cannot but be favorably impressed, for the plants are operating with utmost satisfaction. In fact, all things seem to assert that the day of the high power gas engine has just dawned.

Great as has been the success of the above type of four-cycle gas engine, it yet has a formidable rival, namely, the two-cycle engine. The two-cycle engine is not new. Its qualities have been known for years. Although it is not as economical or convenient in small sizes as the four-cycle engine, it is peculiarly adapted for large power and constant speed-control. These facts being known, the two-cycle engine has stood idly in the background for years. But with the increasing confidence in the gas engine and especially the recent advent of the high power gas engine, in America, the two-cycle engine is rapidly coming to the front. The double-acting two-cycle will soon be competing sharply with the four-cycle double-acting tandem and twin-tandem.

Right here it might be well to enumerate briefly the advantages and disadvantages of the two-cycle engine as against the four-cycle.

ADVANTAGES OF THE TWO-CYCLE

(1) Twice as good speed regulation per cylinder as the four-cycle because the explosions occur twice as often.

(2) Takes up less room because we get double the power per cylinder.

(3) Reduction of necessary valve mechanism. A two-cycle double-acting engine of one cylinder is equivalent to a four-cycle double-acting of two cylinders. The four-cycle has four admission valves and four exhaust valves, all mechanically operated. The two-cycle has two mechanically actuated inlet valves, and two exhaust ports having no operating mechanism whatever. Valve troubles then are practically divided by four.

(4) Costs less for above reasons, (2) and (3).

(5) Scavenging with air from air pumps gets rid of products of combustion which, in the four-cycle, remain in the clearance space and dilute the incoming charge. It is a fact often marked in the hit-or-miss four-cycle engine, that the first explosion after missing one or more cycles, is always an extra powerful one. This is due to the scavenging effect of drawing in and expelling air during the preceding inactive period.

DISADVANTAGES OF THE TWO-CYCLE

(1) Short time is allowed for scavenging and admission, both being accomplished in about one-tenth of a stroke, while in the four-cycle each has a whole stroke. This scavenging is satisfactorily done, however, with pumps or compressors to force the air and gas into the cylinder at a great velocity.

(2) Danger that some of the mixture being admitted will go out with the exhaust before the port closes. Great care must be taken in design and adjustment to prevent this. But it can be prevented.

(3) Mechanically, the design of the two-cycle is yet in a more or less experimental stage and best methods are not well defined or understood. This obstacle is a great hindrance at present, but must necessarily be overcome in the natural course of future development.

A logical conclusion from the above would seem to point to the two-cycle as the gas engine of the future for high power, and as the most satisfactory solution of the problem of speed regulation.

The third obstacle that has confronted the gas engine, namely, *inability to stand an overload,* appears to be an

inherent disadvantage, which must be obviated rather than overcome. We can readily design a steam engine to give its best economy at full load and at the same time be able to stand a maximum of 150 per cent. To be sure, the steam engine will be very inefficient at such an overload, but that is immaterial, since it is overloaded for only a small fraction of the time. With the gas engine, however, the economical load and the maximum are very nearly the same, so that the only way to design a gas engine for an overload is to under-rate it. This accomplishes the desired result, but at the expense of economy on the average load; for the efficiency of the gas engine, like that of the steam engine, drops considerably under partial load.

Some one has suggested that the cylinder head of the gas engine be made to slide in and out like a piston, thus varying the clearance and keeping the compression constant for varying amounts of mixture. This is a very ingenious proposal, but seems to present so many mechanical complications as to be scarcely feasible.

Mr. H. G. Stott, in his paper on "Power Plant Economics" before the American Institute of Electrical Engineers two years ago, proposed that gas engines, for power generation, be operated in combination with an equal capacity of low pressure steam turbines. A steam turbine is remarkably responsive to fluctuations in load, and will also readily stand an overload of 100 per cent or even more for a short time. Moreover, the steam turbine is very economical at varying loads compared with other prime movers; the drop in efficiency from full load to half load, or full load to double load, being very small. The turbines in the proposed plant could utilize some of the jacket water of the gas engines for feed water and could use the heat in the exhaust gases to make steam. In this way it seems possible both to run the gas engines at an economical load and to operate the turbines at a minimum expense.

At any rate, even if it is necessary to under-rate the gas engine, and hence operate it most of the time at less than economical load, still the economy of the gas engine is so high that the all-day efficiency would exceed that of the steam engine plant. Moreover, the efficiency curve of the gas engine under varying load has a smaller slope to the horizontal than that of the steam engine: that is to say, the decrease in efficiency when running under partial load is less for the gas engine. Thus it would appear that the inability to stand an overload is not as important an objection to the gas engine as many believe.

AN IOWA PORTLAND CEMENT PLANT.

By George M. Shepard, '09.

The growth of cement and concrete construction has been enormous in the West and Northwest during the past several years. In spite of this fact 85 per cent of the total cement supply of the United States is manufactured east of the Mississippi river, and 60 per cent of this amount in the Lehigh region of Pennsylvania. In order to obtain cement, then, dealers and consumers must import their product from long distances, involving high freight rates and vexatious delays. To supply the increasing demand and also to make a profit by paying smaller freight rates, the cement industry is at present being developed in the West.

The prime requisites for a successful cement plant are: First, an abundance of raw material easily procured, and secondly, suitable railroad facilities for the marketing of the finished product. With this in view, during 1905, in the northern part of Iowa, the prospectors of the Northwestern States Portland Cement Company located a large strata of limestone closely underlying the surface. In the same vicinity an extensive deposit of clay was found. The raw materials were well situated for Portland cement manufacture. In addition to this, the five railroads entering Mason City would give a wide Northwestern market for the proposed plant.

Samples of limestone were taken by core drills at different depths over the area, and these, with samples of clay, were submitted to the company chemist. The chemist reported that a fine grade Portland cement could be made by a proper combination of the two materials. About 1000 acres of land were purchased, and in 1906 work was commenced upon a modern cement plant of 3,500 barrels daily capacity.

The plan of the plant is approximately shown in Figure 1. The shop, store-room, crusher, air compressor and pump-house were first erected, of which the last three were temporary in nature. The air compressor was used to supply air for pneumatic drilling and riveting before the permanent power-house was completed. The pump-house was used for temporary water supply, although when the plant is in operation all pumping is done at the power house. The temporary

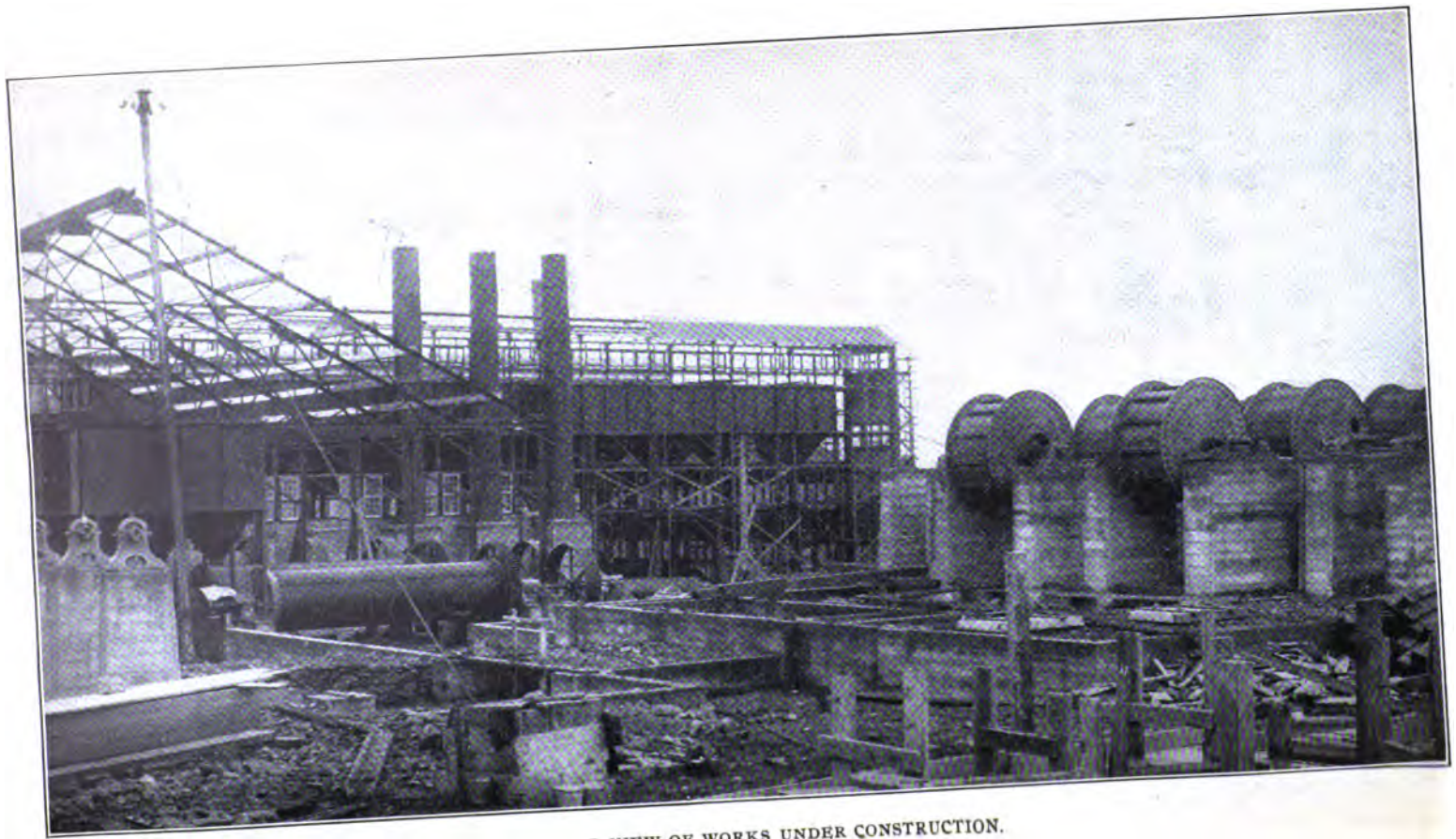


Fig. 5 GENERAL VIEW OF WORKS UNDER CONSTRUCTION.

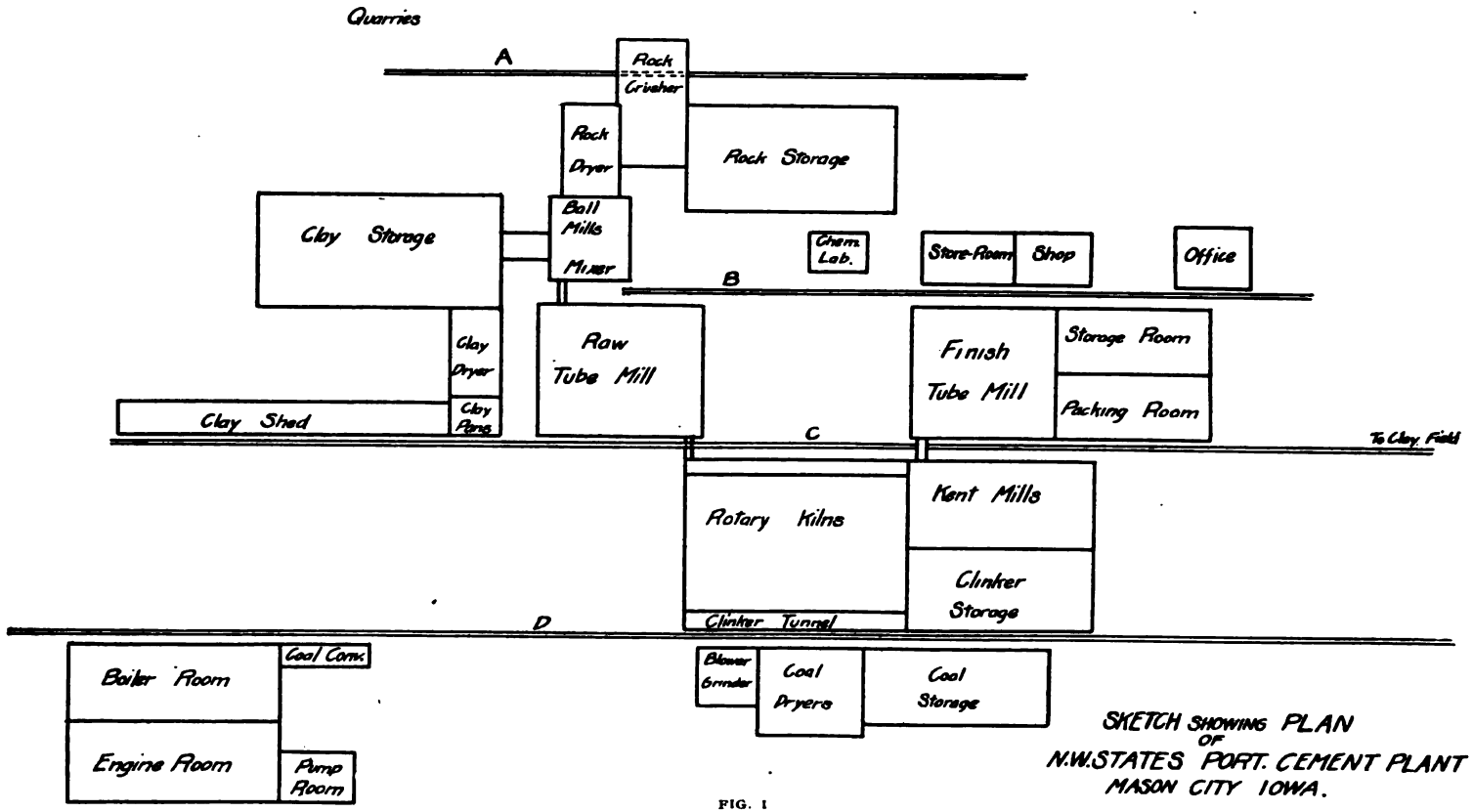

Quarries
A
Rock Crusher
Rock Dryer
Rock Storage
Clay Storage
Ball Mills
Mixer
Chem. Lab.
Store-Room
Shop
Office
B
Clay Dryer
Clay Pans
Clay Shed
Raw Tube Mill
Finish Tube Mill
Storage Room
Packing Room
C
To Clay Field
Rotary Kilns
Kent Mills
Clinker Storage
Clinker Tunnel
D
Boiler Room
Coal Conv.
Engine Room
Pump Room
Blower Grinder
Coal Dryers
Coal Storage
SKETCH SHOWING PLAN OF N.W. STATES PORT. CEMENT PLANT MASON CITY IOWA.

FIG. 1

LARGE CRUSHER.

...ry were made and the machines placed before the frame of ... bridge was erected. The method was this: After the piers had set a sufficient length of time, temporary tracks were laid to them. The machinery, such as the ball-mills in Figure 4, or the small one her in Figure 3, was then unloaded directly from flat cars onto the foundations by means of a steam crane, thus saving a great deal of manual labor. The mill buildings are in general of the forms shown in Figures 3, 5 and 6, and

are of fireproof construction. The structural work for these buildings was let out to an independent steel company.

The economic arrangement of the plant is very good and is such that from the raw to the finish stage there is no unnecessary conveying of materials. In conveying the dried material from one mill to another, in general it may be said that the horizontal work is done by screw conveyors, and the vertical work by elevators placed in vertical shafts. In this part of Iowa the ground is frozen during five months of the year, so that it hinders the excavation of clay. In order to

Fig. 3 BALL MILLS AND SMALL CRUSHER.

insure a supply for winter there are two large storage sheds in the field in addition to the one at the plant. These are filled during favorable weather and are used to keep the mill in operation during the winter months. Although not entirely finished, the greater part of the construction work was completed during the summer of 1907, and hence the mechanical processes of making cement will be briefly outlined in the following paragraphs:

The clay is hauled in dump cars from the field by a truck engine, and onto the trestle C, where it is automatically dumped into the long shed shown at the left of Figure 1. From this shed the clay, in large lumps, is conveyed to the clay pans. These consist of a rotating pan four feet in diameter with a vertical shaft at the center. Upon each side of the shaft is a heavy roller, so that when the pan is in operation the lumps are crushed by the rollers. Clay direct from the field contains a great deal of moisture, and hence the drying process is next in order. There are three dryers, cylindrical riveted steel plate tubes about 6 feet in diameter, and 60

feet long, similar to the kilns shown in Figure 6. The dryers are supported upon trunions and are driven by gearing, as shown in Figure 6. There is a slight slope, so that the clay is fed in at the higher end and gradually works down to the lower end, where the hot air blast enters. Although the temperature is not sufficient to vitrify the clay, the interiors are lined with firebrick. From the lower end of the dryers the clay is conveyed to the storage room, or through a small crusher and directly to the mixer, according to the demand

Fig. 4 RAW TUBE MILLS.

for raw material. The clay storage is a large hopper-bottomed concrete building, in which the dried clay is stored for use during night and winter runs.

While the construction work on the plant was going on the quarries were being stripped of loose soil by means of an elevating grader and dump wagons. This earth was used in making fills for the railroad to the clay field, and for various depressions about the grounds. When work in the quarries begins the rock is blasted, loaded by steam shovel and hauled upon the trestle A above the large crusher shown incomplete in Figure 2. All rock passes through this crusher, where the larger fragments are broken up. The two smaller crushers at the right of Figure 3, with the two jaw crushers to be placed upon the piers directly below, complete the preliminary crushing. The process of drying is the same as that ex-

plained before. When in place one of the rock dryers rests upon the trunions shown in the center of Figure 3.

The ball mills, six of which are shown at the right of Figure 5, further continue the reduction of the rock. These mills are cylindrical in shape, being about 7 feet in diameter and 3 feet wide. Grinding is accomplished by the rotation of these cylinders with 25-pound steel balls inside, which grind the particles of rock to a fine powder. The ball mills are made in Germany and are of especially heavy construction in order to withstand the shocks to which they are subjected.

Fig. 6 ROW OF KILNS

The mixture of the clay and rock is next in order. The proportion of each is determined by the chemist and the mixing is automatically accomplished by a scale which governs the flow from two hoppers into the mixer. The mixer is a large rotating tube. The mixing and grinding is accomplished by large sized flint stones rolling about inside. These flint stones are especially prepared for the work in Europe. The larger ones are 5 or 6 inches in greatest dimension. This grinding action by the flint stones, or "Danish pebbles," as they are called, is carried on still further in the raw tube mills which are shown in Figure 4, and at the right of Figure 5. After passing through these the mixture is of great fineness and is ready to be calcined in the kilns.

The rotary kilns are shown in the extreme background of Figure 5 and the interior of the building in Figure 6. There are 10 of these kilns, 6½ feet in diameter and 110 feet long,

with spaec for two more in case the capacity of the plant be enlarged. They are supported upon trunions and are driven by a shaft extending the entire length of the building. Each kiln is arranged so that it may be thrown in or out of gear without stopping the others. The kilns are heated by powdered coal blown in at the lower end by compressed air, and are continually kept at a temperature of 1,800 degrees F.

The expense of heating a kiln up to this temperature is so great that a kiln is operated day and night, only being stopped for relining with fire-brick or other repairs. The speed of revolution is about one revolution per minute. During the operation the raw material is fused into clinkers varying in size up to large marbles. These clinkers come out of the lower end at white heat and fall upon a continuous conveyor, where water is sprayed upon them to cool them to a lower temperature. Upon this conveyor the clinker is carried through the cooling tower to two coolers. These are similar in form to the kilns, but contain dashers inside, which break up the clinker and give surface for radiation of heat. From here the clinkers pass to the storage.

From storage the clinker passes to the Kent mills, in which they are crushed to powder. After passing through these about ½ per cent of gypsum is added to the product to give it a specified set. The cement is then conveyed across the tracks C to the finish tube mills (similar to those shown in Figure 3), where the final grinding is made by the "Danish pebbles" until the cement is of specified fineness. Upon leaving these mills the finished product is placed in storage to season, after which it is packed and put on the market.

The power for operating this plant is furnished by three 1,800 horsepower compound Corliss engines, two engines being run continuously, and the third alternately. All machines are driven electrically by motors, the current for which is produced by the three alternating current generators at the power-house. The plant has large storage facilities and enough raw material may be stored to keep it in operation during the entire winter.

The writer is indebted to the Northwestern States Portland Cement Company of Minneapolis for the views showing the different phases of the plant.

CHARACTERISTICS OF STEAM LOCOMOTIVES.*

By Edward P. Burch.

In order to understand the use of electric motive power for heavy railway trains, the engineer should not only be acquainted with the characteristics of the different types of motors used on the electric locomotive, but he must be well posted on the physical and operating characteristics of the steam locomotives already in service. Practical experience in steam locomotive tests and with dynamometer cars is therefore most advantageous.

Electrical engineers should at least duplicate the performance of the steam locomotive before suggesting a radical improvement in the motive power service, and in all these matters an intimate knowledge of the characteristics and of the strength and weaknesses of the steam locomotive is necessary. The furnace, the boiler, the limitation of design, the indicator cards, the relation of speed to drawbar pull, the dynamometer records, the effect of railway grades, of underload and overload, the results of weather conditions and all the characteristics of the motive power should be studied. Much is to be learned from the 40 years of crystallized experience shown in modern locomotive design and performance.

Steam locomotives in common commercial service generally have the following physical characteristics:

1. **A self contained power unit** with water supply, coal supply, boiler and engine—a power house on wheels, located and moving between a 4 ft. 8.5 in. rail gauge, at speeds up to 60 miles per hour, during 10 to 16 hours per day. The daily mileage varies from 100 to 250 miles per day, but averages 130 miles except in congested districts.

2. **The water supply** from lakes, rivers, streams, wells, etc., located 10 to 20 miles apart. Alkali water and muddy water must be used in many cases.

3. **The best coal** on the market. It is the screened lump coal, often hauled one and one-half times over the division on which it is used before it is burned. Coal sub-sta-

* Part of third lecture on the subject "Electric Traction for Railway Trains" for senior electrical and mechanical engineers, 1908, by Edward P. Burch, Consulting Engineer, Minneapolis, Minn.

tions are located 20 to 50 miles apart. The power required to haul this coal and water supply at the head of the passenger or freight train is a large portion of the total power.

4. **A compact boiler** of the fire tube type and a fire-box furnace for hand firing. About 200 pounds of steam pressure is used, not for economy so much as for capacity. Feed water heaters, purifiers and superheaters are not used. The heat radiation is large and requires 400 pounds of coal per hour per idle locomotive. The square feet of heating surface is equal to about 460 times the volume of the cylinder for passenger engines and 400 for freight. The ratio of heating surface to grate surface averages 70. In operation the grates must often burn several different kinds of coal on a long run. It is well known to a designer that the grates and exhaust nozzle producing the draft can be suited to but one grade of coal at a time; thus other grades are burned at a disadvantage. This is the cause of some of the firemen's complaints regarding poor coal. The draft and rate of combustion is induced by and is proportional to the exhaust discharged into the smoke-stack. The boiler cannot furnish sufficient steam to sustain the maximum tractive force when the speed exceeds 10 miles per hour.

5. **Two simple engines.** Only 6 per cent of all locomotive cylinders are compound, and these are run on the level division of the road. Steam consumption in service varies from 25 to 35 pounds, averaging 30 pounds per indicated horsepower. Cylinder diameters are so proportioned that at 90 per cent theoretical cut-off, the steam pressure will slip the drivers with 22 per cent coefficient of adhesion between rails and the weight on the drivers. The length of stroke is 22 to 32 inches—the longer stroke for heavy freight service—the 26 inches for passenger and for ordinary service. Piston speeds are commonly 1,200 to 1,400 feet per minute. The diameter of drivers varies from 48 to 84 inches, or about one inch per mile per hour the engine is expected to run.

6. **A high center of gravity** for the narrow track gauge. The center of gravity is in the boiler, at a height above the top of the drivers. The diameter of driving wheels of ordinary passenger locomotives is commonly 60 to 84 inches; of freight locomotives 55 to 63 inches; of switching and logging locomotives 48 to 51 inches.

7. **A wheel base** varying from 28 to 30 feet in length. A 14 to 17 foot driving and rigid wheel base is common with eight coupled and consolidation locomotives.

8. **The design** of locomotives to work all materials, fuel consumption and frequently the labor, to the highest possible limit.

9. **The maximum tractive effort**, or draw bar pull, proportional to the steam pressure, the square of the cylinder diameter, the length of the stroke, and inversely as the diameter of the driver wheels. The draw bar pull by design is made equal to 22 per cent of the weight on drivers. The draft gear of the cars in the train is limited to about 36,000 pounds in practice. This draw bar pull may be exerted when one or two locomotives are coupled in the usual way at the head of a train. Generally articulated types of locomotives, like the Mallet compounds, which may exert from 60,000 pounds draw bar pull as a maximum to 50,000 pounds continuously are used as pushers. The reciprocating motion of the pistons does not furnish uniform tractive effort or draw bar pull. The result in the starting of freight trains is noticeable.

10. **The weight of a locomotive limited by:**

The number of wheels which can be used on curves.

A weight of ten tons per wheel, which can be borne by the rails. The Pennsylvania R. R. standard is two tons per linear foot of track.

11. **Large frictional losses.** The design of the steam locomotive necessitates relatively high losses due to friction in the reciprocating parts, in the pistons, cross heads, valves, rods and connecting links, the resistance to rolling offered by trucks and tender, and the resistance due to the shape of the locomotive.

Aspinall found that the ten-wheeled engine with tender absorbed 34 per cent of the total power. W. M. Smith has given the result of his experiments as about 30 per cent of the total power; and Mr. Druit Halpin has found that the engine absorbed 57 per cent of the total power developed; while Dr. Dudley gave it as 55 per cent; Mr. Barber at 48 per cent. These figures appear very high. Probably less than 30 per cent is the proper percentage for ordinary trains, the actual figures depending upon the speed, the wheel base, the degrees of unbalancing and the load behind the engine and its coal and water tender.

12. **The capacity limited by design.** To increase the capacity of locomotives, we first load the driving wheels to the greatest allowable or safe weight the rails will bear; say 80 tons for 80-pound rail. The number of driving wheels is generally limited to four pairs in freight and three pairs in

passenger engines. A rigid driving wheel base is limited to 16 or 17 feet on account of curves. The driving wheels are made of such diameter that the reciprocating machinery will not work at a higher speed than 1,400 feet per minute. The cylinder diameter must provide sufficient tractive power. The boiler is to be placed above the wheels clear of the drivers, and with enough heating surface to supply the steam. The grate must have a size which will burn the needed quantity of lump coal. The fire-box must have a length, depth and breadth which is ample, that the flames will be kept out of contact with the top until the combustion is completed. The fire-box must be so designed as to prevent excessive overhanging. The design of fire-box is exceedingly difficult on account of the support, shape, expansion and warping.

Large steam locomotives are not satisfactory. The failures in the locomotive itself multiply as the size increases. The men operating the moving boiler and engine plant are not sufficiently skilled, nor can they give the machinery sufficient attention. James J. Hill, in his address before the Commercial club at Kansas City, Nov. 16, 1907, said:

"The men in charge of the railways in this country have struggled for nearly fifteen years with the greatest problem of our times—how to move a load whose weight increases from 10 to 15 per cent a year with an engine whose power increases at about 2½ per cent a year. The limit of safe, speedy and reasonable service with existing facilities has been reached."

The Mallet type articulated compound locomotives, Great Northern Railway Type L I, the largest steam locomotives yet built, weigh over 300 tons. The heating surface is 5,700 square feet. The grate surface is 78 square feet. Weight on drivers, 316,000 pounds. Weight of engine, 355,000 pounds. Weight of tender loaded, 148,200 pounds. Total weight, 503,200 pounds. The steam pressure is 200 pounds. Cylinders are compound 25.5 inches and 33 inches by 32 inches stroke. Authority Toltz, N. Y. Ry. Club, Sept. 20, 1907. They are said to have cost $34,000 each. Two firemen are required. Each locomotive is designed to haul an 850 ton train at 9 miles per hour up a 2.2 per cent grade and around curves. At 9 miles per hour, the coal consumption is stated to average 3.0 pounds of coal per draw bar horsepower, but at all higher speeds the coal consumption is much heavier. The table below shows the locomotive characteristics:

Miles per hour	Draw bar pull	Per cent of draw bar pull	Draw bar h. p.	Train tons
0	54700	85.0	0	820
5	54000	84.0	700	880
9	52500	81.7	1260	825
10	50500	77.8	1345	815
15	44500	69.0	1780	725
20	38000	59.0	2050	570
25	30500	47.5	2040	420
30	22500	35.0	1800	270
35	14000	21.8	1315	100
37	0	0	0	0

The high pressure cylinder is back of the low pressure, on each side of the locomotive. The two cylinders on each side may, in articulated types, work anywhere from synchronous position to 45 degrees from each other. The latter gives the most uniform crank effort.

The horsepower capacity of steam locomotives is based on 12 pounds of steam per square foot of heating surface per hour, and 28 pounds of steam per indicated horsepower hour. H.P. $= 12/28 = .43$ square feet of heating surface. The horsepower of common locomotives seldom exceeds 1,200. At the low speeds, 10 to 12 miles per hour, the cylinder is not filled too frequently to tax the boiler.

The draw bar horsepower equals draw bar pull $\times$ speed in m. p. h. $\times$ 5,280/60/33000, or $T \times S$ /375.

The torque, or pounds at the rim of the drivers, or tractive force, or the draw bar pull, depends on: The steam pressure of the boiler in pounds per square inch (P), the diameter of the cylinders in inches (D), the length of stroke in inches (L), the diameter of the drivers in inches (W), multiplied by a factor (Y), which is the ratio of the mean effective pressure to the boiler pressure.

The **maximum** tractive force, or torque, is $P \times D^2 \times L/W$ pounds multiplied by the factor, Y, which at slowest speeds is .85 and at highest speed is .25 of the boiler pressure.

The piston speed is $S \times 60 \times 3.14 \times W/5280 \times 2 \times L$, or $S \times W/56 \times L$ in feet per minute.

The **operating characteristics** of steam locomotives are:

1. **The furnace conditions** or fuel economy are not good. Stokers with tile arches cannot be used.

2. **A high rate of evaporation** reduces the efficiency of the boiler.

3. **Cold weather reduces the efficiency** of the boilers. It increases the radiation and condensation and at a time when the tractive effort should be decidedly greater due to increased journal friction.

4. **The amount of steam used** is high per draw bar horsepower. Superheat, condensing operation, and feed water heating are not used. The condensation in the boiler and cylinder is large.

5. **The horsepower** developed by the cylinders is a minimum on the heavy grade and is a maximum on the level.

6. **Lack of capacity per pound** of weight is to be noted. About 22 pounds per horsepower is common, compared with 8 pounds in electric locomotives. The capacity per dollar invested in equipment, including the coal and water supply for the locomotive proper, is small.

7. **The boiler and engines** are generally too complicated and large to get proper attention from the engineman and fireman.

8. **The reciprocating parts** increase the locomotive and track repairs.

9. **The steaming power of the boiler** is limited and thus the horsepower is limited.

10. **The mean effective pressure** decreases rapidly after the speed passes 10 m. p. h., or at a piston speed of 400 feet per minute.

11. **The wear on the track material** is proportional to the engine weight.

"Assuming the same neglect of upkeep, engines with low wheel bases and small drivers will not roll as hard as high ones. Modern high-wheeled passenger engines throw track out of line."—WILSON.

Moguls and engines with long rigid wheel base are hardest on track. Engines with high center of gravity are hard on curves. The nozing of engines, due to the alternating thrusts of pistons on each side of the locomotive, loosens the rail spikes, causing rail spreading and wrecks. The amount of the unbalanced weights in ordinary drivers is large, because the proper counter-balance in the drivers can be suited to but one speed.

The torque, or tractive effort, of steam locomotives depends largely upon the peculiar way in which the steam is utilized. Studying then the principal characteristics of the locomotive indicator cards in figure 2 we will note:

1. **A short stroke,** 24 to 32 inches.

2. **A high piston speed,** 1,000 to 1,400 feet per minute. The revolutions per minute depend upon the diameter of the drivers and the length of the stroke.

3. **A high initial steam pressure**—200 pounds per square inch.

4. **The large loss of pressure** at normal speeds between the boiler and the steam chest, varying from 2 per cent in

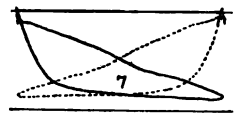
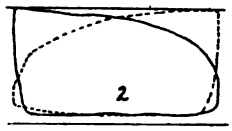
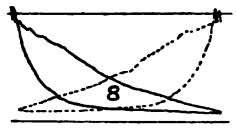
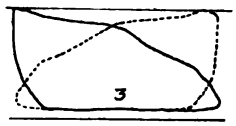
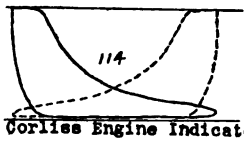


FIGURE-2

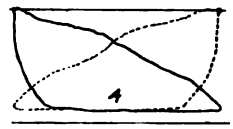


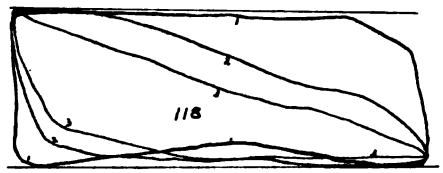




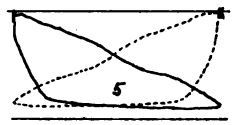


Corliss Engine Indicator Card.



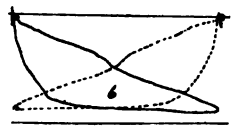


Starting Card.Freight engine 901- Head End- 140# spring, 20" x 32"



TEST ON NORTHWESTERN TYPE LOCOMOTIVES.
Locomotive 80 tons, tender 50 tons,20"x26", with 80" drivers hauling a 450 ton all coach passenger train. Heating surface 3016 sq.ft.
A.E. & R.J. Nov.'00.

Card	B.P.	M.E.P.	% B.P.	Cut-off	M.P.H.	Piston speed	H.P.
1	195	182.5#	93.5%	21"	slow	slow	small
2	190	120.0	63.1	10 3/4	30	546	1256
3	195	99.1	50.8	12	40	728	1383
4	185	76.3	41.2	11 1/4	50	910	1331
5	185	63.5	34.3	10 5/4	60	1092	1325
6	170	52.7	31.0	10 5/4	65	1183	1195
7	180	47.7	26.5	8 1/2	70	1274	1165
8	175	55.2	31.2	10 3/4	70	1274	1338



STUDY OF INDICATOR CARDS. PASSENGER AND FREIGHT ENGINE A150 CORLISS ENGINE.

BURCH 1908

starting to 10 per cent at a piston speed of 700 feet per minute, and to 15 per cent at 1,400 feet per minute; also an abnormal loss due to wire drawing in the ports and passages between the steam chest and the cylinder.

5. **A most indefinite point of cut-off** and of release, due to the type of valve in general use.

6. **The compression** beginning near the middle of the return stroke.

7. **Large condensation** on the walls and on the exposed piston rod. The hyperbolic curve of expansion is not followed.

8. **The clearance** between the piston and the valve seat is from 8 to 10 per cent of the volume of the stroke.

9. **A back pressure** due to restricted exhaust amounting to 10 to 20 per cent of the initial pressure. It may be 50 per cent if the drivers slip in starting.

10. **The cut-off** showing poor expansion and an uneconomical utilization of steam. The number of expansions are seldom over three.

11. **At low speed** in starting, the largest card and the greatest mean effective pressure and a high back pressure.

12. **As the speed increases,** the cut-off being late, say ¾ cut-off, the mean effective pressure decreasing, due to a reduction in the initial pressure received at the cylinder and a large increase in the back pressure.

13. **The size of the card** and the mean effective pressure controlled by the cut-off to a very limited extent.

14. **At high speeds** a comparatively small card, notwithstanding the fact that there may or may not have been a change in the cut-off. This is due largely to wire drawing past the valves.

15. **The speed** affecting the distribution of the steam, the thermodynamic efficiency, also the machine friction. When the piston speed reaches and exceeds 1,000 feet per minute, the loss due to wire drawing and due to condensation decreases the mean effective pressure faster than the thermodynamic gain and faster than the mechanical gain due to the increase in piston speed.

16. **The amount of steam** consumed increasing as the speed increases, up to the boiler capacity. The reason the boiler is overloaded on the heavy grades at low speeds (the engine doing but one-third of maximum indicated horsepower), is due to the uneconomical use of steam at the late cut-off.

17. **The mean effective pressure decreasing as the work and speed increases.**

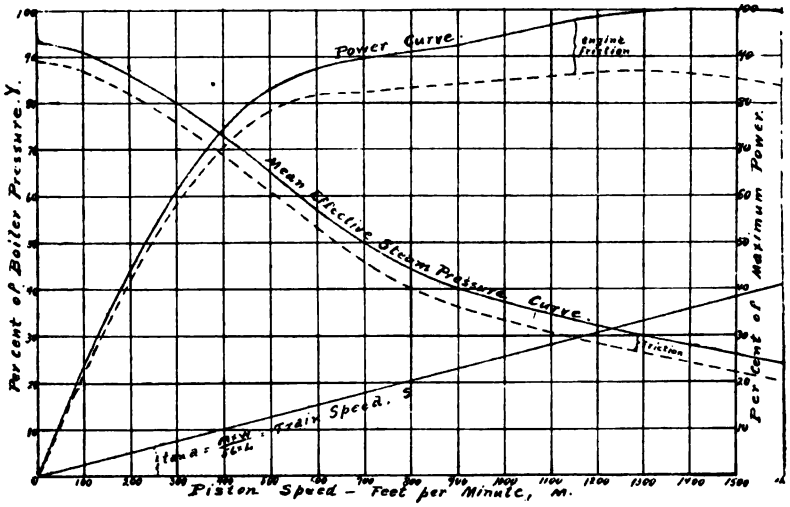
There can be no general relation between the mean effective steam pressure and revolutions per minute, independent of the length of the piston stroke, as some early writers have thought. The relation is between the mean effective pressure and the piston speed.

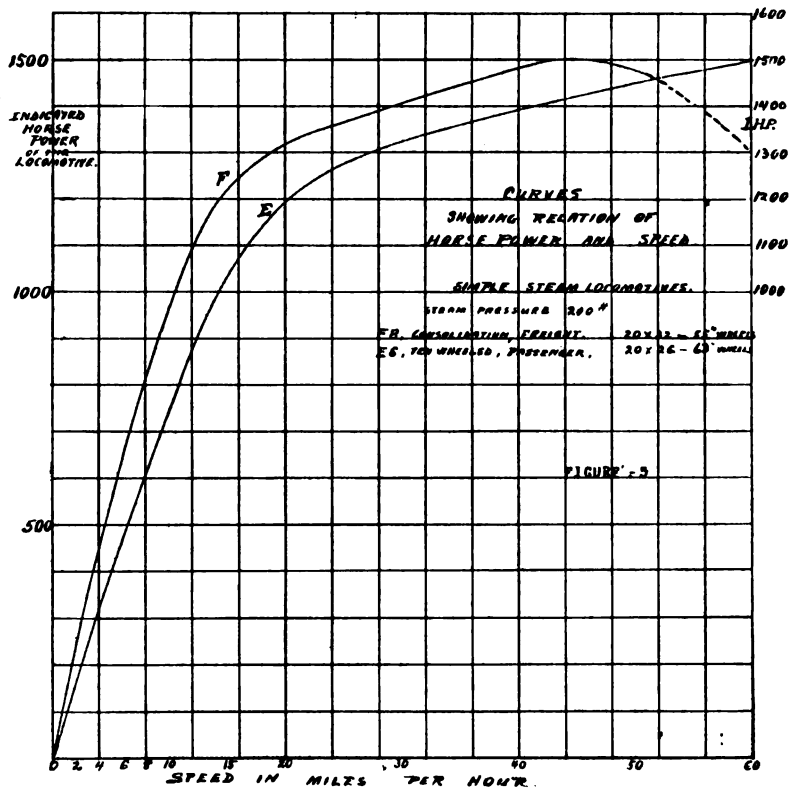
If the cut-off is too great for the piston speed, the mean effective pressure will tend to decrease, due to back pressure, assuming of course that the boiler heating surface is ample to maintain the initial steam pressure.

The relation between the mean effective steam pressure and piston speed is shown by one of the curves in Figure 3. This curve was first plotted on a large scale from the results of hundreds of indicator diagrams, and it establishes an average result for general use. The relation between the power and piston speed is also shown. From Figure 3, we are able to obtain the curve of indicated horsepower and speed in miles per hour, when we know the steam pressure, size of cylinders and diameter of drivers of a particular locomotive. Such curves for two well known locomotives are shown in Figure 5.

It is a well known fact that there is a critical piston speed for each locomotive, beyond which the relative mean effective pressure decreases faster than the piston speed increases. Therefore there is a critical speed for each locomotive beyond

CHARACTERISTIC CURVES OF SIMPLE STEAM LOCOMOTIVES. FIGURE 3.





which the horsepower curve does not increase, and further increase of speed (on the down grade) shows a decrease in horsepower.

The work done, or the indicated horsepower, of steam locomotives, is quite constant for all speeds including small grades. The load diagram of steam locomotives is therefore nearly a horizontal line when plotted on a time base. This is shown in figure 5, also in the comparative data on New York Central locomotives which follow:

Locomotive	Steam		Electric	
Number	2797		3401	
Type	Pacific		Gen. Elec.	
Weight total	171 tons		98 tons	
Weight on drivers	70 tons		70 tons	
M. P. H.	Pull	H.P.	Pull	H.P.
0	35000	0	35000	0
10	35000	935	35000	935
20	30000	1600	35000	1870
25	24000	1600	35000	2337
30	19000	1520	35000	2805
35	16000	1495	32000	3000
40	14000	1495	20000	2135

The horsepower of the steam locomotive is limited by the capacity of its boiler. Therefore, as the speed increases there is a proportional decrease in the draw bar pull. The horsepower of the electric locomotive is limited by the capacity of the central station behind it, and the draw bar pull can be sustained, to a considerable degree, as the speed increases. Thus the electric locomotive has superior starting or accelerating characteristics which make it valuable, aside from its greater capacity.

EDITORIALS.

The Engineers' Society has grown from a mere beginning in 1887, until it is today a powerful and influential organization of 175 members. The Year Book, the record and mouthpiece of the society, has developed until the present copy is a substantial volume of 150 pages, recognized as a publication of considerable technical value, and found in all the leading libraries of the country. The Engineering College today has no means of expressing or announcing its current news. Many, probably the majority, of the engineering graduates have considerable trouble expressing themselves in clear, comprehensive English when called upon to do so. In view of the above facts, the present Board of Editors wishes to propose the following for consideration by the alumni, the future boards, and the students.

Namely, that the Year Book be changed from an annual to a semi-annual or quarterly publication. This we feel is not too radical, as the present book carries over a hundred pages of literature, and forty pages of advertising, which, with a small addition, would make four fair sized copies. There are several considerations involved in the publication of a quarterly that are not so pronounced in that of an annual.

Our plan for a quarterly follows: The dates of issue could be November, January, March and May. The first number could be a thesis number, publishing extracts or complete copies of the best of the theses of the previous year. These often contain excellent and valuable material and data, which should be circulated among the students, and cannot be handled in any other way. These, together with possibly the positions held by last year's graduates, the new additions to the engineering faculty, the recent development of the five-year course, the progress of the new engineering building and other current news, would make a very respectable volume of 35 pages.

Number II in January, might continue any desirable thesis matter, take up a review of the first semester's work, discuss any new or desirable electives and contain current news and articles written by undergraduates.

Number III in March should continue the same line of work.

Number IV, in May, should be similar to our present Year Book, containing articles of wider engineering value, by outside and experienced men.

The great value of the Minnesota Daily, the Gopher, the Magazine, or Minnehaha, while all excellent in themselves, lies in the training and experience obtained by the student editors and authors. It seems to us that if we can get the engineers interested both in writing articles and in editorial work, it will do much toward equipping them so that they can intelligently and clearly express themselves in the technical press and elsewhere, as they may have occasion to do. The prime idea of our new five-year course is to introduce a general, broad training into the engineers' technical work. Now it seems to us that a quarterly would almost be equivalent to a course in engineering journalism—something that is needed in our five years of work. The men in five years would be older and more mature, and we think this plan would be especially feasible.

The expense of getting out four volumes would, of course, be somewhat increased. However, the value of advertising space depends upon the number of times it is seen; that in quarterly being several times as valuable as in an annual. As a large number of the advertisements would run throughout the year, the work of business manager would not increase proportionately. An assistant business manager would work in nicely and leave an experienced man to start things the following year.

As to the editorial staff. One way would be to let each assistant editor have one of the first three numbers as his particular charge, the editor-in-chief taking the last one, having it understood, perhaps, that the assistant who got out the best number would be recommended for editor-in-chief for the next year. Thus the work would be concentrated, and, we think, not too heavy for any one man.

The present board feels that the Engineering College needs and should have a publication of this kind. We feel that the time is here for it, and with the advent of our new building and five-year course, we see great possibilities for the Society and a publication of this nature. We wish to bring the matter before the alumni, the Society, the faculty and the students of the engineering college. Any advice or criticisms will be gratefully received by us, and our successors.

We are informed that in the plans now under way for the enlargement of the campus, provision is being made for a group of engineering buildings commensurate with the dignity and importance of the College of Engineering. The need for such a group of buildings—for an engineering quadrangle—in which the college can be truly said to have a home is keenly felt by faculty, students and alumni.

The present scattered trio of buildings is neither adequate in size nor satisfactory in arrangement. The old Mechanic Arts Building, serviceable in its time, has long since outlived its usefulness. The Department of Civil Engineering deserves a newer and larger home; the experimental laboratory has outgrown the space allotted to it. The university lighting and heating plants, now separately conducted, should be combined into one modern, economical unit.

All these improvements could and should be accomplished by setting aside that portion of the new campus lying between Church street, State street, Northern Pacific tracks and Washington avenue for the exclusive use of the College of Engineering. Upon this ground a compact group of buildings, including a new experimental laboratory, civil engineering building and power plant could be erected. These, together with the Mechanical and Electrical Engineering buildings now built, would form the engineering quadrangle.

The College of Engineering would then have a home; the efficiency of the various departments would be increased; the spirit of the college would be quickened by a more intimate and unified student life.

PROCEEDINGS OF THE SOCIETY.

The Engineers' Society was called to order, for the first time, September 27, by President Currie, for a special business meeting. Business Manager Zimmerman gave a report of the financial condition of the '07 Year Book, which was satisfactory and accepted. It was decided to hold the annual "boom" meeting in the near future and to confer with Dean Jones as to the date.

A rousing mass meeting was held in the Physics Lecture Room, October 11, at which Dean Jones, Professors Constant, Flather, Haynes, Shepardson and Cutler gave short, inspiring talks. The good results of this meeting manifested themselves in the large membership for the year.

The aim of the Engineers' Society has always been to benefit its members, both by hearing and being heard. In this, our success has been greater this year than ever before; our student talks forming an important part of the year's program. The order of our regular meetings has been a business meeting first, followed by two or more talks by members, upon subjects in which they are interested, or have had considerable experience.

Following is the list for the past year:

October 22.

"Features of the Westinghouse Course," by President Currie.

"The Iron Business on the Pacific Coast," by H. Cole Estep, '08.

November 8.

"Traction Engine Tests," by E. N. Stacy, M. E., '07.

"Construction of a Switch Board," by L. P. Zimmerman, '08.

December 6.

"Construction of an Alternator," by R. S. Prentice, '08.

"Construction of a Viaduct," by H. H. Knowlton, '08.

"Rapid Electro-chemical Analysis," by F. C. Frary, Chemistry, '04.

January 22.

"Manufacture of Hydraulic Cement," by O. B. Poore, '09.

"Gas Engine Manufacture," by L. B. Sperry, M. E., '05.

February 19.

"A Telephone Switch Board," by E. Weber, E. E., '06.

For many years we have felt the need of a good course of lectures on the various phases of practical engineering. Thru the untiring efforts of our dean, F. S. Jones, acting on the society's continued suggestion, the Board of Regents this year appropriated three hundred dollars to secure a suitable lecture course for the Engineering College. As a result we have had the good fortune to hear the following able men on the subjects listed below:

January 24.

"A Day in the Auditor's Office of a Great Railway," by Frank Nay, General Auditor for the C., R. I. & P. Railway, Chicago.

February 25.

"Irrigation and Reclamation of the Arid Lands in the West," by C. J. Blanchard, of the United States Reclamation Service. This was the best illustrated lecture ever given at the University; our only regret is that everyone did not have a chance to hear it.

March 5.

"Suggestions to Prospective Engineers," by D. C. Morgan, of the State Railway and Warehouse Commission.

March 9 and 10.

"A Million Dollar Bridge" and "Ethics of Engineering," by J. A. Wadell.

March 24.

"Timber Preservation," by G. L. Wilson, Chief Engineer of the Twin City Rapid Transit Company.

April 24:

"Railway Signaling," by R. L. Classen, Division Superintendent of C., M. & St. P. Railway.

Dr. H. T. Eddy of the Graduate School also favored us with a very interesting illustrated lecture on the "Theory and Practice of Modern Steam Turbines as Power Units."

We wish to tender our hearty thanks and appreciation to each one of the above men, for all that they have done toward a broader engineering education for the members of the Engineers' Society, and the men of the Engineering College.

On November 17, 1907, at the St. Anthony Falls Commercial Club, was held the first of the semi-annual banquets. Mr. Frank Scobie acted as toast master, and the following responses were made:

Dean F. S. Jones: "Our Lecture Course."

Professor Shepardson: "Engineering Humor."

R. J. Cobban, '09: "The Men's Building and the Engineer."

R. F. Cox, '08: "The Engineers' Society in the Days of '03."

H. D. Frary, '08: "The Slide Rule—An Aid to Thought."

H. Cole Estep, '08: "Student Editors."

L. P. Zimmerman, '08: "The Year Book as a Business Proposition."

The second banquet will be given May 15, and promises to be even better than the first one.

With the present year's success to build on, the coming year ought to make the Engineers' Society and the Engineering College of the University of Minnesota, "The Best in the West."

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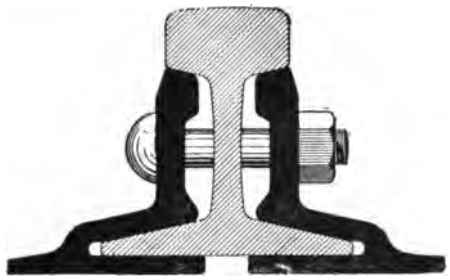

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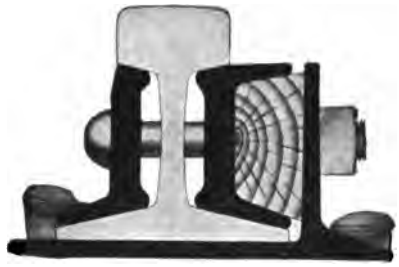

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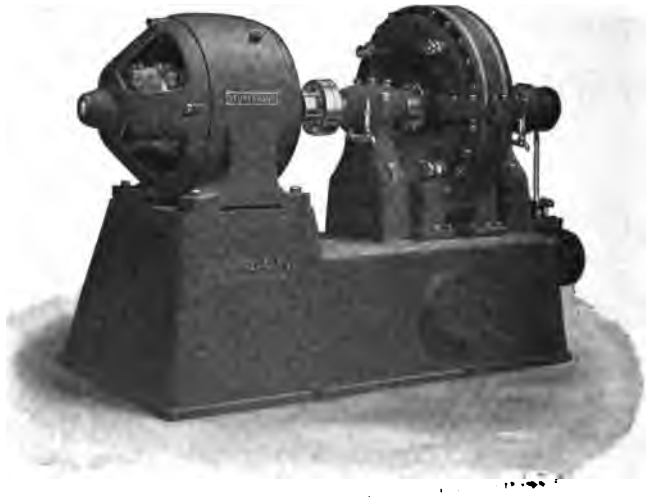

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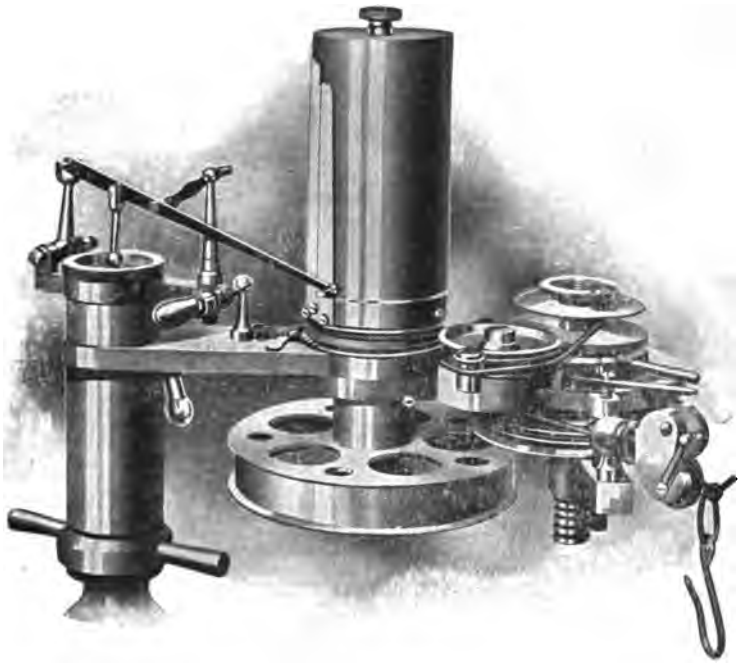

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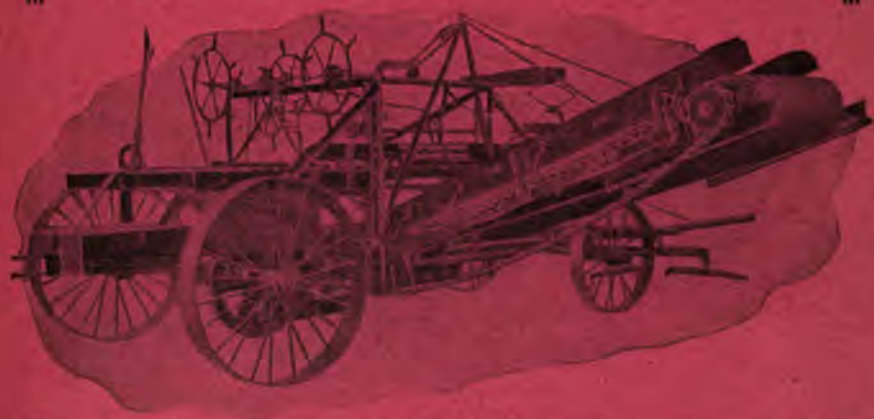

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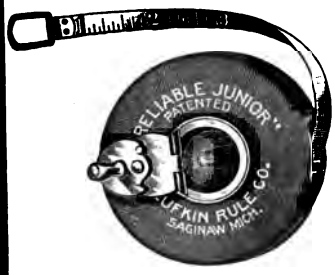

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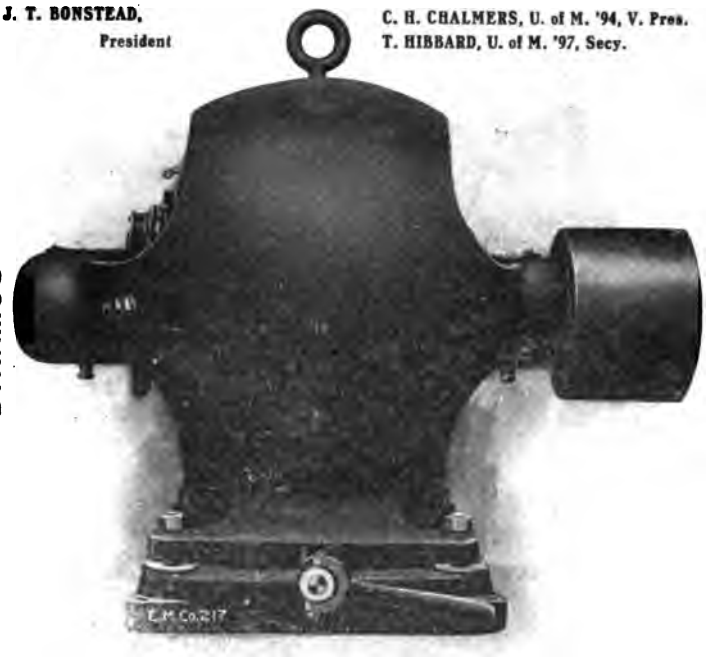

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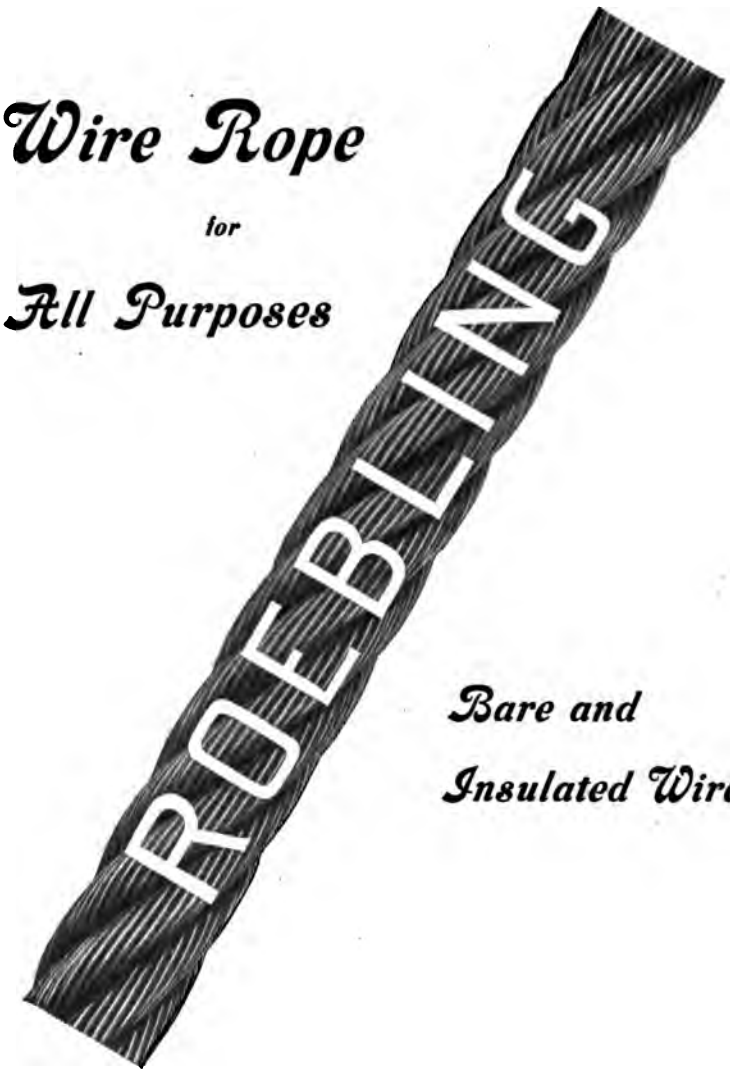

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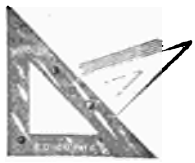

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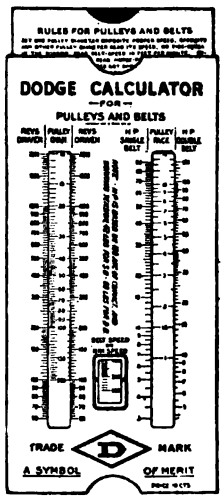

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